NEONATAL OUTCOMES RELATED TO SCHOOL READINESS IN AN URBAN KINDERGARTEN POPULATION

By

Lawrence D. Reid, MPH

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ABSTRACT

Background: Research shows that students beginning school ready to learn have more productive and healthier adult lives and that students from lower income families are less likely to begin school ready to learn. This study examined whether neonatal outcomes influenced school readiness in an urban population and whether childcare and neighborhood characteristics modified this association.

Methods: A retrospective cohort study of 39,463 first time kindergarten students from 2002 to 2012 in a large urban public school district was conducted by linking student's readiness scores to their birth certificate data and neighborhood characteristics based on the maternal census tract of residence. Multivariate hierarchical linear models examined differences in mean school readiness scores of low birth weight (LBW) and preterm birth (PTB) students adjusting for student and parent characteristics and the clustering of students in cohort years, schools and neighborhoods.

Results: Respective prevalence of LBW and PTB was 13.7% and 14.6% in the study sample. Fifty percent of students attended a district PK program while one-quarter of students received informal home care (23%) or family child care (3%) in the twelve months before entering kindergarten. Adjusted results showed LBW and PTB were independently associated with lower readiness scores and that prior care type significantly modified the relation between LBW and school readiness. Readiness scores were highest for students who attended a district funded PK program and lowest for those who received no formal care. Readiness gaps by birth weight were observed in these groups but not in other PK and center based care programs. Neighborhood characteristics were related to school readiness, but did not modify the relation between LBW and school readiness.

Conclusions: LBW and PTB were associated with lower school readiness; prior childcare modified this relation. Scores were highest for district PK students. Expansion of publicly funded PK programs in low-income urban public school districts may better prepare students for school than other childcare types, including private nursery PK programs and other center based childcare programs. The birth weight disparity in readiness among district PK students highlights the need for improved early childcare programs in the school district.

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COMMITTEE OF FINAL THESIS READERS

Committee Members	**Department**
Dr. Donna Strobino, Ph.D.	Population, Family and Reproductive Health
Dr. Anne Duggan, Sc.D.	Population, Family and Reproductive Health School of Medicine Mental Health Health Policy and Management
Dr. Pamela Donohue, Sc.D.	School of Medicine Population, Family and Reproductive Health
Dr. Nicholas Ialongo, Ph.D.	Mental Health

Alternate Committee Members	**Department**
Dr. Mary Elizabeth Hughes, Ph.D.	Population, Family and Reproductive Health
Dr. Keshia M. Pollack, Ph.D.	Health Policy and Management

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE

BACKGROUND AND SPECIFIC AIMS

Introduction

Some of the best universities in the world are located in the United States (US), but US students academically fall behind students in secondary education from other developed countries. A recent international study of test scores among 15 year olds conducted by the Organization for Economic Co-operation and Development (OECD) ranked US students 14th overall among other OECD countries across math, science, and reading subjects. The reasons for America's lag in leading the world in educational performance include a variety of factors such as poor education systems, insufficient federal funding of schools and school systems, and poor quality teaching. A key to ensuring that American students can compete with other nations academically as young adults is ensuring that they are prepared and ready to begin school in early childhood. For example, approximately half of the Black-White test score gap in American high school students is evident when children start school in kindergarten (Phillips, 1998).

An important determinant of how children start school in kindergarten is the students' family income level (Magnuson, 2004). Nowhere is this more evident than in low-income urban settings like Baltimore City where rates of school readiness are consistently lower than other districts in Maryland. President Obama understands that in order to improve American students' academic standing in the world, greater attention must be given to improving early childhood education. He explained in his 2013 State of the Union address that:

> *"Initiatives in manufacturing, energy, infrastructure, and housing will help entrepreneurs and small business owners expand and create new jobs. But none of it will matter unless we also equip our*

citizens with the skills and training to fill those jobs. And that has to start at the earliest possible age.

Study after study shows that the sooner a child begins learning, the better he or she does down the road. But today, fewer than 3 in 10 four year-olds are enrolled in a high-quality preschool program…. And for poor kids who need help the most, this lack of access to preschool education can shadow them for the rest of their lives… In states that make it a priority to educate our youngest children… studies show students grow up more likely to read and do math at grade level, graduate high school, hold a job, and form more stable families of their own."

- President of the United States,
Barack H. Obama
February 12, 2013

To that end, the primary goal of this dissertation is to provide insight into the reasons students in urban districts like Baltimore City are not entering kindergarten ready to learn at higher rates. Using kindergarten Maryland Model for School Readiness (MMSR) data from the 2002-03 to 2012-13 school years (SY), we studied the relation between birth characteristics of students and their parent and early childhood academic success, as defined by kindergarten school readiness, among Baltimore City Public School (BCPS) students, after adjusting for other student and neighborhood characteristics. The specific aims were three-fold, to:

Aim 1: Determine whether LBW (<2500 grams) and PTB (<37 weeks gestation) are related to school readiness among Baltimore City kindergartners, adjusting for maternal and child characteristics at birth.

Aim 2: To assess whether type of prior care moderates the relation between LBW and PTB and school readiness, after adjusting for other student and maternal characteristics.

Aim 3: To examine whether Baltimore neighborhood characteristics modify the relation between LBW and PTB and school readiness, adjusting for maternal and child characteristics at birth and prior care characteristics at school entry.

Background

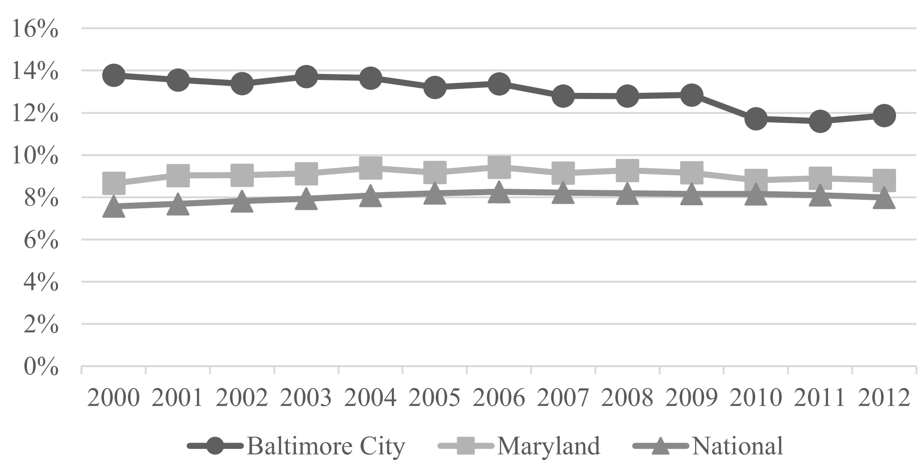
Indicators of school readiness of three to six year olds have improved nationally over the past two decades. The percentage of pre-kindergartners with the ability to recognize letters, count to at least 20 and write their own names increased between 1993 and 2007 (O'Donnell, 2008; Chandler, 1999). Unfortunately, low-income pre-kindergarten students did not experience similar improvements on these basic indicators of school readiness over the same period. With anywhere from 1 in 5 to 1 in 4 children living in poverty today in the US, according to recent Census reports (Short, 2012), it can be expected that poverty will continue to have a deleterious effect on school readiness rates for the foreseeable future. As he indicated in the State of the Union address, President Obama, recognizing the dire situation of children from low-income families, proposed to invest $75 billion over 10 years to provide high-quality preschool to more communities. In fact, it is "the cornerstone of the President's education investments [to] expand high-quality early learning opportunities to all 4-year-olds from low- and moderate-income families" (USDE, 2014).

The state of Maryland has made educating its youngest children a priority. Since the late 1990's, Maryland has employed a framework for early education teachers and child care providers to help determine the progress of students at very young ages. Beginning with the 2001-02 school year (SY), the Annie E. Casey Foundation, the Maryland Subcabinet for Children, Youth and Families, and the Council for Excellence in Government convened leaders of state and local government and advocacy and service organizations to form the Leadership In Action Program (LAP) 5-Year Action Agenda. This group developed the goal of ensuring that all children in Maryland, birth to age 5, enter school ready to learn. In turn, the Maryland Model for School Readiness (MMSR) assessments of students' preparedness in kindergarten (and more recently, pre-kindergarten as well) was initiated (MSDE, 2013).

Positive MMSR results have been observed across Maryland school districts since implementing the MMSR assessment, but students in Baltimore City Public Schools (BCPS) continue to lag behind other students in Maryland districts. In the first year (SY 2001-02), 49% of all Maryland kindergarteners were assessed as "Fully Ready" for kindergarten. In that same year only 28% of all Baltimore City Schools kindergartners were rated "Fully Ready". This twenty-one percentage point gap in school readiness has been cut in half according to the most recent MMSR results showing 83% and 73% school readiness rates among kindergarten students in Maryland and BCPS, respectively. Despite an overall greater increase in school readiness rates, BCPS still has the lowest kindergarten school readiness rate of all school districts in Maryland (MSDE, 2013).

The lower prevalence of school readiness among BCPS kindergarten students compared to other districts in the state may be due to its urban setting, characterized by factors that contribute to lower academic performance. These factors include, among others, higher enrollment of low-income, minority and physically and mentally disabled students, a lack of quality, affordable child care, and persistently higher rates of adverse birth outcomes, like low birth weight (LBW) and preterm birth (PTB), that influence the trajectory of early childhood development. In 2012, 11.9% of all live births in Baltimore City were LBW, surpassing the state and national rates; this difference has persisted for at least the past decade (**Figure 1**), although LBW rates have dropped somewhat in Baltimore City in recent years. Further, studies show direct links between LBW and developmental delays in children (Arpino, 2010; Aarnoudse-Moens, 2009). Studies have also shown that academic outcomes at school entry vary by the type (Coley, 2013; Forry, 2013) and, to some extent, the quality of care (Abner, 2013) provided to children in the years prior to school entry.

Figure 1. Low birth weight (LBW) rates, by geographic area, 2000-2012



Source: Martin, 2013; MDHMH, 2012

In light of these trends in school readiness rates, a better understanding of the upstream determinants of school readiness in an urban context are needed to help improve academic outcomes of children in urban areas like Baltimore City. Prior research on early childhood development of children born with adverse birth outcomes has been limited by small sample sizes and a narrow focus on simple math and reading abilities of school age children for assessing school readiness (Keller-Margulis, 2011). There is also a paucity of population-based studies focused on children from low-income families and neighborhoods, even though an abundance of prior research shows that children from these vulnerable settings are less likely to possess school readiness attributes at school entry (Magnuson, 2007). More robust assessments of the factors associated with school readiness, particularly for low-income LBW and PTB children, are needed to develop a better understanding about what can be done to increase school readiness in urban low-income populations.

A population-based study was undertaken to address the aforementioned aims. The study serves to benefit students, parents, early childhood care and education practitioners, education administrators, and city public health officials by identifying specific risk factors that may pose as barriers to school readiness success in urban US school districts, like Baltimore. Increased awareness of these risk factors and the aspects of school readiness they are most likely to affect may help improve the design of early childhood development intervention programs which, in turn, may help to improve academic achievement for students in urban settings like Baltimore City. Examining variation in the specific domains of school readiness across neighborhoods and birth types may also help to clarify the specific social and environmental characteristics that deter school readiness among children born LBW in urban cities. The consequences of adverse birth outcomes like LBW are particularly salient in Baltimore where high rates of LBW may affect early childhood development and subsequent school readiness.

Dissertation Overview

This introduction begins the five chapters of this dissertation. Chapter two consists of a literature review of prior research on the developmental outcomes of children born with adverse birth outcomes and a discussion of the potential impact children's type of prior care and neighborhood characteristics may have on developmental outcomes. The conceptual framework is also described in chapter two. A description of the study design, data, and analysis methods are covered in chapter three, and chapter four summarizes the results. A discussion of the main findings is provided in chapter five along with a description of the study's strength and limitations as well as the implications of these findings and conclusions.

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CHAPTER TWO

LITERATURE REVIEW AND CONCEPTUAL FRAMEWORK

Overview

This literature review covers research about school readiness and risk factors for not being ready for school. The first section describes the definition of school readiness, how it has traditionally been measured, outlines recent trends in students' school readiness, and describes the importance of school readiness to public health in general. The second section describes the biological and social risk factors for not being ready for school. This section also highlights the need for research into more robust measures of school readiness and its determinants. The third section describes the influential properties of prior care settings on the relation between neonatal risk factors and school readiness. The fourth section describes the potential effect of neighborhood characteristics on the relation between birth characteristics and school readiness, and highlights the need to better understand community characteristics that impact school readiness of low birth weight (LBW) and preterm birth (PTB) children. As a conclusion to the literature review, the final section highlights the importance of the proposed study by describing the gaps in the extant research regarding school readiness levels of LBW and PTB children. The fifth section outlines the underlying conceptual framework for this dissertation based on the findings from the literature review.

School Readiness

What is School Readiness?

School readiness is generally defined as the extent to which students enter school ready to learn. Put another way, "school readiness refers to the state of child competencies at the time of school entry that are important for later success" (Snow, 2006). Barring neurological impairments, all children possess an inherent ability to learn.

In practice, school readiness is more an assessment of how well the student's early environment may or may not have prepared the child for school. Assessment of a child's development at school entry, however, is not conducted with the goal of denying entry to students who do not show or show little signs of school readiness. Rather, the goal is to draw attention to children's lives and their developmental trajectories within the context of their environments prior to school entry (Copple, 1997), and to identify children in need of attention.

School readiness as a construct appeared in the literature around the same time as the emergence of formal education and schooling (Gessell, 1925). Then, and now, debate has centered around when children should begin schooling; although more recently debate has shifted to understanding when is it best for a child to begin school given the child's developmental characteristics (Snow, 2006). There are several perspectives regarding the way children learn and what children should be prepared to know and do at school entry (Andrews, 2001). The prevailing perspective, or model, is the maturationist model which advocates the view that school readiness is biologically a function of the child's age and level of cognitive, psychomotor, and emotional maturation. Most US states adopt this perspective based on age requirements for students to start prekindergarten or kindergarten (Saluja, 2000).

Other models of school readiness have been proposed. The environmentalist model suggests that children become ready to learn in school through the acquisition of skills learned from early socialization experiences. Constructivists posit that school readiness is the degree to which children can learn tasks through interactions with their peers and adults. The cumulative-skills model sees children's possession of particular prerequisite skills necessary for learning a particular subject as an indication of school readiness. The transactional model views school readiness as an interaction between children's developmental status and their environments. A recent seventeen state effort to develop statewide indicators of school readiness adopted the transactional approach to school readiness (KIDS COUNT, 2005).

Regardless of the adopted perspective, early childhood education (ECE) research has generally shown that school readiness is comprised of three important characteristics: 1) the ability of students entering school ready and able to learn, 2) schools being prepared and ready to teach students, and 3) the presence of neighborhoods, communities, and structural environments that are supportive of students in their academic efforts. Indeed, school readiness in its broadest sense involves engaged and supportive families, effective schools, and safe and nurturing communities that foster the development of prepared children (Maxwell, 2004).

Some concern exists about the use of school readiness assessments. Inappropriate use of school readiness assessments has called into question the objectives of conducting these assessments. ECE practitioners have used school readiness assessments alone to delay grade promotion or classify children with disabilities (ELSTF, 2005; Graue, 2006; Keating, 2007). Use of readiness data to label a student as a slow or difficult learner for the life of their academic career is inappropriate. Most assessments are not designed to be predictive of future performance (Snow, 2006). School readiness measurement alone is not an appropriate determining factor for these decisions. For this reason, the goals and expectations of school readiness assessments should be clearly stated and outlined prior to conducting such assessments (Graue, 2006; Keating, 2007).

How is School Readiness Measured?

School readiness assessments typically involve measuring how students have developed across several important domains right before kindergarten, at kindergarten entry, or very early in the kindergarten year. The National Education Goals Panel (NEGP) identified five domains of children's development and learning imperative for school success: physical well-being and motor development, social and emotional development, cultural differences in learning approaches, language development, and cognition and general knowledge (Kagan, 1995).

In 2000, states and local school districts varied in the way students were assessed for school readiness, primarily because a definitive definition of school readiness did not, and still does not exist. A common theme of state assessments, however, involved identifying the "deficits" of young students as they enter school in kindergarten or around age five. Deficits here refer to "the things children cannot yet do or do not know such as the letters of the alphabet" (Farran, 2011). To address variation in assessments, the Early Childhood Education Assessment-State Collaborative on Assessment and Student Standards (ECEA-SCASS) was created. This group identified 5 cornerstone attributes for assessing children:

1. Acknowledge early childhood as a time of rapid developmental changes;
2. Consider academic knowledge and skills in the context of the whole child;
3. Provide child development information over time in naturalistic classroom settings;
4. Develop assessments that are reliable, valid, and fair; and

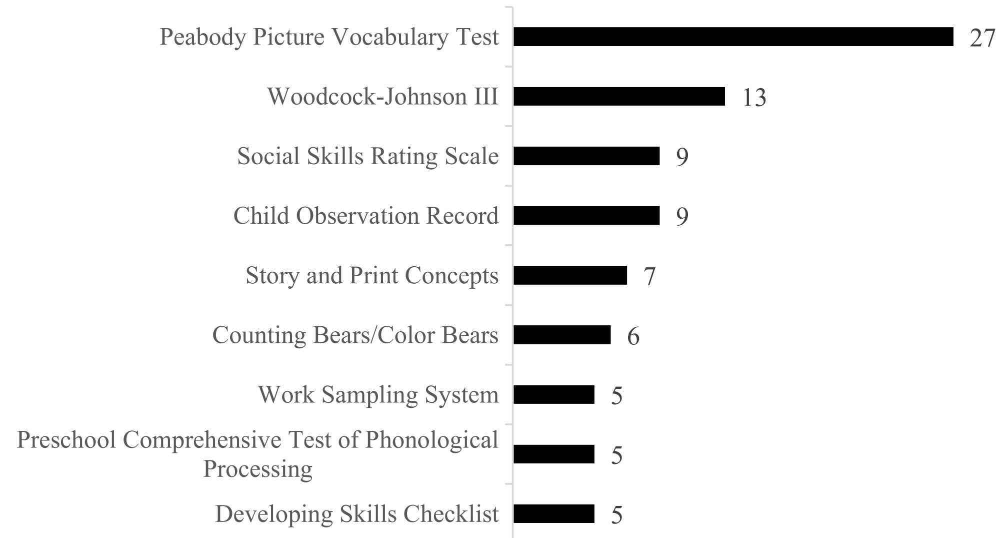
5. Assessments should be developmental and linked to kindergarten curriculum (ECEA-SCASS).

The ECEA-SCASS recently conducted a review of current efforts in kindergarten readiness assessments. The review noted that assessments conducted prior to, at the start of, and during kindergarten are useful for a number of purposes if done well. Findings from the review suggest that effective assessments should adhere to the following:

- Use multiple tools for multiple purposes,
- Address multiple developmental domains and diverse cultural contexts,
- Align with early learning guidelines and common core standards,
- Collect information from multiple sources, and
- Avoid inappropriate use of assessment information, specifically including high-stakes decisions, labeling children, restricting kindergarten entry, and predicting children's future academic and life success (Howard, 2011).

Instruments used to assess kindergarten school readiness vary across states. Some states allow local assessments to be conducted while many require a state mandated assessment be carried out in each district. According to a recent report from the Council of Chief State School Officers, 25 states have laws that mandate a kindergarten assessment be conducted, representing an increase of 72% from 2005 to 2010 (Daily, 2010). A 2007 review conducted by the US Department of Education (USDE) found that instruments used to assess kindergarten school readiness across states included observational measures, standardized measures, checklists, teacher ratings, and teacher surveys (Brown, 2007). Most states employed multiple instruments to collect information on children's skills and abilities across multiple domains. Based on the USDE's review, the most frequently used instruments to assess school readiness by state are the Peabody Picture Vocabulary Test (Dunn, 1997), followed by the Woodcock-Johnson III (McGrew, 2001), Social Skills Rating Scale (Gresham, 1990), and, used less frequently, the Work Sampling System (Meisels, 1998) (**Figure 2**).

Figure 2. Number of studies in USDE's school readiness review using different school readiness assessment instruments, 1997 - 2006.



Source: Brown, 2007

The first state in the nation to create a comprehensive tool for assessing children's school readiness was Maryland. Maryland's MMSR Kindergarten Assessment Program incorporated all five recommendations of the ECEA-SCASS when the state began assessing school readiness among its kindergarten students in the fall of 2001. This program uses the valid and reliable Work Sampling System (WSS®) Kindergarten Checklist, a curriculum-embedded performance assessment that guides preschool and kindergarten teachers through child assessments over the course of a year instead of at one static-point like many norm-referenced assessments (Meisels, 1995). The assessment conducted in the fall of each SY serves as the measure of school readiness in the state. The MMSR goes beyond the domain guidelines of the ECEA-SCASS and assesses kindergarten school readiness across seven domains: social and personal, language and literacy, mathematical thinking, scientific thinking, social studies, the arts, and physical development and health. Students are rated Fully Ready, Approaching, or Developing within each domain and for a composite of all domains.

Similar to state assessments of school readiness, independent ECE research on the academic abilities of school-age children born preterm have typically collected data from multiple traditional, standardized measures of academic outcomes and parent and teacher reports of skill functioning and service utilization (Keller-Margulis, 2011; Sullivan, 2003). In their review, Keller-Margulis et al (2011) identified 20 studies from 2000 to 2010 indicating that children born preterm have academic skill deficits compared to full term peers. Assessment of academic skills in these studies was often done by combining portions of the Woodcock-Johnson Tests of Achievement (WJTA; Woodcock, 2001) with the Reading Comprehension Subtest of the Wechsler Individual Achievement Test (WIAT; Wechsler, 2001). The Wide Range Achievement Test (WRAT; Jastak, 1984) was often the instrument chosen when a single test was used. Approximately half of studies used parent or teacher reports and over half procured data directly from school records. School functioning and disability status (service utilization) were included in thirteen of the twenty studies, but school-based disability status was only confirmed in five studies.

School Readiness Trends

Nationally, parent reports of their children's prekindergarten (PK) ability to recognize all 26 letters of the alphabet rose from 21 to 32 percent between 1993 and 2007 according to the National Center for Education Statistics; the percentage of children able to count to at least 20 rose from 52 to 63; and the percentage able to write their names rose from 50 to 60 percent. Poverty severely affects PK school readiness. In 1993, the gap between children above and below the poverty level who recognized all letters, counted to 20 or higher, and were able to write their name was 12, 16, and 12 percentage points, respectively. By 2007, the respective gaps widened to 14, 18, and 18 percentage-points (O'Donnell, 2008; Chandler, 1999).

The pervasive effects of poverty will continue to negatively impact school readiness as long as a quarter of American children continue to live in poverty (Short, 2012). In studies involving nationally representative samples, the non-Hispanic (NH) White – Black gap in school readiness has persisted (Fryer, 2004; Brooks-Gunn, 2003; Hillemeier, 2011), but whether the gap has widened or narrowed is difficult to assess due to the different methods of assessing readiness over time (Rock, 2005).

School readiness among Maryland kindergartners (roughly 5 years of age) showed large gains in the percentage of students rated "Fully Ready" for school since students were first assessed in the fall of 2001. The percentage of students rated "Fully Ready" for school in the fall of 2011 was 83% compared to just 49% in 2001, a 69% increase in readiness. Gains in school readiness were observed across gender and race. Although gains were also observed in subgroups defined by students with disabilities (SWD), English language learners (ELL), and free and reduced priced meals (FARMS; a proxy for low-income status), gaps actually increased for SWD students. In 2001, the difference in school readiness among SWD (30%) and general education (GE, 50%) was 20 percentage-points, increasing to 26 percentage points in 2011 (MSDE, 2013).

Gains have been made in school readiness rates among Baltimore City kindergartners since the fall of 2001 for each aforementioned subgroup, despite having the lowest school readiness rates in Maryland. The gap in readiness for SWD and FARMS students, however, increased in Baltimore City Public Schools (BCPS). In 2001 only 13% of SWD and 28% of general education (GE) students were rated as fully ready for school. In 2011, despite overall increases, this 15 percentage-point gap increased to 26 percentage-points with 49% of SWD and 75% of GE students rated fully ready for school. The change in school readiness among FARMS students is somewhat surprising. In 2001, there was essentially no difference in the school readiness of FARMS (27%) and non-FARMS (28%) students. A six percentage-point gap was noted by 2011 with 78% of non-FARMS students rated as fully ready compared with 72% of FARMS students (MSDE, 2013). The increased disparities in kindergarten school readiness occurred despite a 50% increase in available PK seats in Baltimore City from approximately 3,000 seats in the fall of 2007 to roughly 5,000 seats in 2011 (BCPS, 2011).

The reasons for the increased gap in school readiness between low and high income and between SWD and GE kindergarten students are unclear. The change may be due to improved assessment as PK and kindergarten teachers have continually undergone professional development to better understand how to administer the WSS assessment. Changes in the city's population from which the BCPS student enrollment is drawn may also have contributed to the increased gap. As BCPS's total enrollment declined over the past decade, students remaining in the district may be from families unable to transfer to another district due to economic hardship. Developing a better understanding of the reasons for the lower school readiness rates among Baltimore City students can lead to policies for improved pre-school programs as well as to address the barriers to school readiness among low-income and physically and academically challenged students.

Public Health Importance

Researchers from various disciplines, including ECE and maternal and child health (MCH) have documented the deleterious effects of adverse early health and environmental conditions on children's ability to begin school ready to learn. Specifically, studies show that children born PTB or LBW are at risk of developing significant early childhood neurological, behavioral, and developmental delays compared to their term and normal birth weight counterparts (Aarnoudse-Moens, 2009). LBW infants are more likely to have reading and math cognitive disabilities (Breslau, 2001), and preterm infants have higher rates of Attention Deficit-Hyperactivity Disorder (AD/HD) and executive functioning problems (Baron, 2010).

School readiness is important for improving individual and public health. Children who enter kindergarten with early academic skills like basic knowledge of math and reading are more likely to achieve later academic success (Duncan, 2007; Hair, 2006) and have higher levels of educational attainment and employment (Rouse, 2005) than those less academically prepared for school in kindergarten. Conversely, students who experience academic struggles early in their career are more likely to become withdrawn, inattentive, and disruptive. Indeed, students struggling academically in early school years continue to struggle to maintain their grades and attendance, and often drop-out of school (Hertzman, 1996). Dropouts are more likely to engage in illegal behaviors, become teen parents, and to depend on welfare and other public assistance programs to survive

(Shonkoff, 2000; Townsend, 2007) – ultimately costing society exponentially more than the cost to help ensure children enter school ready to learn (Sum, 2009).

Better school readiness in childhood leads to increased educational attainment, and the link between educational attainment and better health outcomes and health behaviors is well documented in the public health literature (Ross, 1995). The importance of school readiness as a mechanism for improving public health is apparent. For schools and school systems, understanding how prepared their students are for school can help create and shape programs, policies, and curriculum for their student population to increase educational attainment. For health departments and early childhood programs like Head Start and other Center-based Early Care programs, understanding the factors that contribute to or detract from school preparedness can help in creating more effective programs.

School Readiness Risk Factors

The following section describes measures of newborn health, PTB and LBW, and reviews how these and other early childhood risk factors are related to school readiness based on prior research. Three main findings will be drawn from this review: 1) LBW and associated neonatal characteristics are significant determinants of early childhood development and subsequent school readiness; 2) knowledge is limited about how different early childhood care settings (i.e. Head Start, Child Care Center, etc.) prepare children for school entry, particularly for LBW children; and 3) the effects of neighborhood level characteristics on the relation between LBW and school readiness are not well understood.

The following review included several recent studies (Lee, 2014; Keys, 2013; Hillemeier, 2011; Fomby, 2011; Isaacs, 2011) using data from the Early Childhood Longitudinal Study, Birth Cohort (ECLS-B). In an effort to better understand risk factors related to early childhood development, the United States Department of Education (USDE) developed the ECLS-B which followed a nationally representative sample of approximately 10,700 children born in the US in 2001. Using birth certificates for the sampling frame the ECLS-B included an oversampling of low (1500 – 2500 grams) and very low (<1500 grams) birth weight newborns and Asian, Pacific Islander, Chinese, and twin children[a].

Childhood assessments were conducted at nine months, two years, and four years of age when children entered kindergarten (either fall 2006 or fall 2007). Data about children's school readiness was gathered by direct child assessment, parent surveys, and teacher surveys. Information about birth characteristics, parents and home environments, and out-of-home care settings was also collected. Developmental outcomes measured in the ECLS-B for four year olds were derived from a battery of assessments that included portions of the PPVT (Dunn, 1997), the Preschool Comprehensive Test of Phonological and Print Processing (Lonigan, 2003), the PreLAS 2000 (Duncan, 1998), and the Test of Early Mathematics Ability-3 (Ginsburg, 2003).

Biological Neonatal Characteristics

As noted above, an important aspect of child development is the ability for children to successfully transition into the formal education setting. Neonatal and perinatal characteristics of birth weight, gestational age at birth, presence of congenital

[a] More information is available at the ECLS-B website: http://nces.ed.gov/ecls/birthdatainformation.asp

anomalies, and labor complications directly influence children's ability and development in early childhood. The quality and type of care and education experiences students received prior to entering school are key to addressing any detrimental effects experienced by these types of risk factors in order to successfully enter school. Equally important are the student's first years of life which set the trajectory of learning by the student during early childhood. The health of the newborn and the home and social environment of the newborn significantly contribute to the trajectory of development for children.

The Centers for Disease Control and Prevention (CDC) defines preterm birth as a live birth prior to 37 completed weeks of gestation (or 259 days between the first day of the last menstrual period to delivery) and LBW as newborns weighing less than 2500 grams (or 5.5 pounds) at birth (Martin, 2013). A 2001 estimate suggests that nearly half of all infant hospitalizations are related to health complications of PTB or LBW, and costs are highest for extremely PTB or LBW (<28 weeks' gestation or <1000 grams) infants (Russell, 2007). In 2005, the annual societal economic burden associated with PTB in the US was estimated to be at least $26.2 billion, or $51,600 per infant born preterm with medical care ($16.9 billion) constituting the majority of these costs (IOM, 2007).

PTB is currently measured on birth certificates using the clinical estimate of gestational age based on several criteria which include the date of the mother's last menstrual period (LMP) and early ultrasound to measure the length of pregnancy at the time of birth (Martin, 2013). Obstetric experts at a National Institute of Child Health and Human Development (NICHHD) sponsored workshop on optimizing care and outcomes for late-preterm (34-36 weeks gestation) infants noted that when assessing an infant's risk level, gestational age, birth weight, the infant's relative size for gestational age, and medical conditions should all be considered (Raju, 2006).

Surveillance data of birth outcomes from birth certificates collected by the US Vital Statistics system is a valuable resource for better understanding adverse birth outcomes and how they impact later social, health, and education outcomes (Schoendorf, 2005). Data from this system consistently show US LBW (UNICEF, 2004) and PTB (Blencowe, 2012) rates to be some of the highest among developed nations. In the US, the rate of PTB increased by 13% from 10.6% in 1989 to a high of 12.8% in 2006; it declined to 11.6% in 2012. The rate of LBW increased from 6.9% in 1990 to 8.3% in 2010 – a 17% increase during this period. The LBW rate was 8.0% in 2012 (Martin, 2013). In 2012, the rate of very LBW births (<1500 grams) among all live births was 1.42%, up from 1.28% in 1989. The 2012 rate of Very PTB (28 – 33 weeks gestation) was 1.93%, slightly lower than the 1989 rate of 1.95%. Non-Hispanic Black mothers have experienced greater LBW and PTB rate declines in recent years than non-Hispanic White mothers.

Preterm births are more likely to experience neurologic and behavioral developmental delays (Aarnoudse-Moens, 2009; Anderson, 2003; Hack, 1994; Arpino, 2010) which can result in lower school readiness at school entry (Reichman, 2005). Studies consistently show that children born very LBW (<1500 grams) and very PTB (<33 weeks gestation) are at greater risk of developmental and neurological deficiencies than their term and normal birth weight counterparts (Arpino, 2010). Infants born too soon do not receive the same gestational benefits of those born at term and are also at greater risk of being born LBW.

The probability for survival of very and extremely PTB and LBW infants is largely dependent on the type and extent of complications experienced in the perinatal period (Landry, 1984). Increases in the viability of these infants is due to improvements in neonatal intensive care management of perinatal complications, the prevalence of developmental deficiencies and conditions also increased (Seri, 2008) among infants born increasingly preterm and LBW (Hintz, 2005). Estimates of developmental disabilities of neonatal intensive care unit (NICU) graduates vary by the cohort studied (Behrman, 2007), but the largest estimated prevalence is in the range of 20 – 25% (Halsey, 1996; Jennische, 2001).

The notion that children born LBW show different developmental trajectories than those born at term was documented as early as 1939 when Shirley described what she called, “the prematurity syndrome”. Based on her subjective observations of 100 LBW infants at The Center for Child Health and Development at the Harvard School of Public Health, she surmised that premature infants, as defined by LBW, exhibited cognitive, motor, sensory, emotional, and behavioral issues and were more “irascible, petulant, shy, negativistic, inattentive, and dependent” than their term normal birth weight counterparts (Shirley, 1939). Despite the subjectivity of these original findings, studies on the developmental outcomes of PTB and LBW children since then have supported some of her original conclusions (Caputo & Mandell, 1970; Drillien, 1964; Fitzhardinge, 1976). In Caputo & Mandell’s review (1970), premature LBW infants were found to exhibit more “deviant behavior”, be “associated with autism”, have lower language and reading development, and exhibit “deficits in physical growth, motor behavior, and neurological functioning”.

More recent studies of the developmental trajectories of LBW infants also generally support Shirley’s original findings. Indeed, studies and meta-analyses consistently show that children born LBW experience more significant cognitive and physical developmental delays and disabilities than children born with normal birth weight (Aarnoudse-Moens, 2009; Anderson, 2003; Arpino, 2010; Escobar, 1991; Hack, 1994; Boulet, 2011; Marlow, 2005; Wood, 2000; McGrath, 2002; Breslau, 2001; Hillemeier, 2011). LBW infants are more likely to be diagnosed with clinical disabilities that include cerebral palsy (Himpens, 2008; Platt, 2007), developmental coordination disorder (Goyen, 2009), visual (Dammann, 2009) and hearing (Ancel, 2004) impairments, in addition to psychiatric disorders like Autism Spectrum Disorder (Schendel, 2008; Johnson, 2010) and anxiety/depression (Saigal, 2003; Lindstrom, 2009). Attention Deficit Hyperactivity Disorder (ADHD) is a commonly diagnosed condition among premature children, with a greater prevalence occurring among very and extreme subgroups (Jeyaseelan, 2006; Valtonen, 2003). In fact, cognitive impairments are the most common and severe disabilities experienced by children born preterm (Arpino, 2010), independent of birth weight (Anderson, 2003; Shankaran, 2004; Bohm, 2002) and other possible confounders like maternal education and socio-economic factors (Breslau, 2001).

Hillemeier et al (2011) studied children from the ECLS-B and identified factors associated with low cognitive scores at 48 months, they included very preterm birth (<33 weeks gestation), low maternal education, and low family income after controlling for other factors collected on birth certificates. The author's also found that among children with low cognitive scores at 24 months, VLBW children (<1500 grams) had more than three times the odds of displaying low cognitive scores at 48 months compared to normal birth weight children; no difference in 48 month cognitive scores by birth weight or gestational age was observed among children with normal cognitive scores at 24 months. These results may suggest that effective interventions for the most at-risk infants must be initiated early in life and maintained throughout early childhood.

Meta-analyses conducted by Aarnoudse-Moens et al (2009) showed that very PTB and/or VLBW births scored approximately half a standard deviation lower on mathematics and reading tests and three-quarters of a standard deviation lower on spelling tests than term-born peers ranging from age five to twenty years old. Anderson et al (2003) estimated that greater than half of very PTB or extremely LBW (<1000 grams) children exhibited neurobehavioral impairments at school age, compared to only a third of normal birth weight children. Prevalence estimates of developmental coordination disorder (DCD) vary dramatically from 9.5 to 51% among premature children (Goyen, 2009; Wocadlo, 2008; Holsti 2002) to only 5 to 6 % in the general population (APA, 2004). An inconsistency in cut-off values for quantifying motor impairments in early childhood make it difficult to obtain reliable prevalence estimates (Davis, 2007). Although inconclusive, it is believed that because prematurity is associated with lower brain volume, and thus, altered white and gray matter volume (de Kievet, 2012), early cognitive disabilities and DCD in premature children are possibly related to delayed and disrupted patterns of neurodevelopment due to altered gray and white brain matter (Nosarti, 2008).

PTB and LBW children are also more likely to need special academic assistance in formal education settings (Taylor, 2011; Corman, 1998) with associated costs for local school districts and governments at millions of dollars to maintain (Chaikind, 1991). Evidence suggests a gradient in school-age abilities based on gestational age (GA) and birth weight (BW) in that the lower the GA or BW the greater the amount and variety of childhood disabilities (Saigal 2000; Klebanov, 1994). In addition to difficulties with reading and writing at school entry (Frye, 2009), LBW children show signs of greater deficits with math and other academic areas (Litt, 2005; McGrath, 2002), after controlling for socio-economic status and other neurodevelopmental deficiencies (Anderson, 2003; Taylor, 2009; Pritchard, 2009). Differences persists among students with similar IQ scores where the academic performance of LBW children remains significantly lower than their normal birth weight (NBW) counterparts (Klebanov, 1994). A child developing any one of these conditions experiences significant barriers to school readiness, but LBW children are three to six times more likely to have three or more developmental disabilities than NBW children over the course of their childhood (Boulet, 2011).

Other neonatal biological risk factors for developmental delays include delivery complications, congenital anomalies, Apgar scores, and poor maternal health and history. Newborns with any one of these conditions are at risk of developmental delays and/or disability during early childhood. Although these conditions are important for describing the health of the newborn, Apgar scores, congenital anomalies, and delivery complications help characterize the health of newborns. The relation between individual factors and early childhood development and school readiness, however is inconsistent.

Resnick et al (1999) found that students with congenital anomalies and labor complications indicated on their birth certificate had a significantly increased odds of being placed in special education in kindergarten in a study of more than 300,000 Florida kindergarten students, adjusting for other sociodemographic and perinatal risk factors. Students with congenital anomalies also had an increase odds of having academic problems like speech and language impairment in kindergarten. Moore et al (2014) found that higher Apgar scores at birth were significantly associated with greater numeracy assessment among Australian kindergartners, adjusting for maternal age, smoking during pregnancy, gestational age, and type of delivery. In contrast, Hillemeier et al (2011) found no significant relation between congenital anomalies and low cognitive scores at age four using data from the ECLS-B; congenital anomalies, however, are poorly reported on birth certificates. Thus, the findings of a relation between the non-prematurity related biological neonatal indicators and school readiness appear to be inconsistent, but warrant further exploration.

Social Neonatal Characteristics

Social and socio-economic risk factors play an important role in early child development. Important social characteristics in early childhood include the race and ethnicity of the child (Hillemeier, 2011; Boardman, 2002; Brooks-Gunn, 2003) and parents (Fram, 2012), maternal (Isaacs, 2011; Breslau, 2001; Hillemeier, 2011) and paternal (Bohm, 2002) educational attainment, family income (Hillemeier, 2011; Isaacs, 2011; Janus, 2007), socio-economic status (SES) (Patrianakos-Hoobler, 2009; Beaino, 2011), maternal age at birth (Moore, 2014), marital status and family formation (Fomby, 2011), birth order (Hillemeier, 2011), and parent-child interactions (Magill-Evans, 2001).

The indicators consistently identified to have a significant impact on school readiness outcomes include some measure of family or maternal income levels, SES, and maternal education.

Income

Positive correlations have generally been documented between family income and student school readiness. Hillemeier et al (2011) and Isaacs et al (2011), using data from the ECLS-B, showed statistically significant positive associations between family income and cognitive outcomes in children at four years of age. Hillemeier et al (2011) observed that children from low-income families (< $10,000) had a higher adjusted odds ratio (AOR) of low cognitive scores (AOR = 7.01, $p \leq 0.001$) than children from families with an income greater than $75,000, after adjusting for other biologic and social risk factors. Children from families with incomes in the range of $40,001 to $75,000 also had greater odds (AOR = 2.52, $p \leq 0.001$) of low cognitive scores at age four. Interestingly, no significant difference in children's cognitive scores by family income level was observed at 24 months, highlighting the potentially delayed early childhood effects of SES on developmental outcomes, or that measures of development are less discriminating at two years of age. The short form Bayley assessment used to assess cognitive functioning at 24 months was not age appropriate for 48 month students. To overcome this barrier ECLS-B designers used a battery of age appropriate tests to measure cognitive functioning of students at 48 months. Another limitation of the study was using a dichotomous variable to define cognitive functioning, which does not allow for an assessment of the variation explained by the set of predictors.

Isaacs et al (2011) observed that an additional $10,000 of average income throughout early childhood was associated with a one percentage point increase in the probability of being school ready at age five, adjusting for other student and family demographics. The effect was more pronounced among low income families such that for families with an average income below $25,000, a $10,000 increase in average income resulted in a seven percentage point increase in the probability of being school ready at age five. Again, school readiness was a dichotomous outcome based on the percentage of children who scored no more than one standard deviation below the average on four continuous measures (math, reading, learning-related behavior, and externalizing behavior) and a parent-reported health status of good or excellent.

Using Canadian Early Development Instrument (EDI) kindergarten school readiness data and an income to family size ratio, Janus et al (2007) observed that children from a family with financial risk (income to family size ratio lower than one) had more than double the adjusted odds of low school readiness (EDI score in the lowest 10^{th} percentile) than children from families not at financial risk.

Education

Maternal education has been consistently shown to be an important determinant of school readiness (Hillemeier, 2011; Isaacs, 2011; Breslau, 2001; Bohm, 2002). Children of mothers with less than four years of college education had a higher adjusted odds of low cognitive scores than children of mothers with at least four years of college education in the ECLS-B (Hillemeier, 2011). Isaacs et al (2011) observed that children of mothers who completed a four-year college degree had a ten percentage point increase in the probability of being school ready at age five than children of mothers who had not completed high school, controlling for other student and family characteristics. Their study also documented a significant, positive impact of paternal education on school readiness; children of fathers with a four-year college degree had a fourteen percentage point increase in the probability of being school ready at age five compared to children of fathers who have not completed high school, adjusting for maternal education, family income, and other student and family characteristics.

In a comparison of urban and suburban Detroit six year olds, Breslau et al (2001) observed that urban children, children of mothers with a high school education or less (compared to college and above), and children of single mothers had significantly lower intelligence quotient (IQ) scores after controlling for birth weight. Other relevant biological, social, and environmental risk factors were not considered in their analyses.

In a prospective population-based study of 359 Stockholm children born between 1988 and 1993, Bohm et al (2002) used the Wechsler Preschool and Primary Scale of Intelligence-Revised (Wechsler, 1999) assessment of cognitive ability. They found that paternal education was "the single most important predictor" of children's IQ at age five for VLBW children; maternal education was a better predictor of IQ for normal birth weight children, however.

Socioeconomic status (SES)

Similar to the relation between income and school readiness, children from lower SES backgrounds are more likely to be less ready to learn at school entry or score lower on readiness tests than children from higher SES backgrounds. Patrianakos-Hoobler et al (2009) studied a cohort of 121 PTB children with respiratory distress syndrome in Chicago using the Bayley Scales of Infant Development (Bayley, 1993) at two and five years old. They found that of the children classified with developmental delay and SES disadvantage (Hollingshead level 5; Hollingshead, 1975) at two years of age, 75% were not ready for kindergarten at age five. Of the children with developmental delay at age two and not SES disadvantaged, 64% were not ready for school at age five. The authors did not present results from a multivariate model so potential confounding could not be assessed, but these findings suggest that SES can be an important protective factor for developmental outcomes in vulnerable children.

Beaino et al (2011) studied a cohort of 1,503 infants born at 22 - 32 weeks of gestation in France in 1997 who were included in the EPIPAGE study (Larroque, 2008). The Kaufman Assessment Battery for Children (Kaufman, 1993) was used to assess children's cognitive ability at age five. Parents' occupational status was used as a proxy for SES. Children whose parents were considered to be low to low-intermediate SES had significantly increased AOR, ranging from 2 – 3.5, for mild or severe cognitive deficiency relative to children whose parents were considered to be high SES.

Race/Ethnicity

Gaps in school readiness by children's racial and ethnic group persist in the US (Rock, 2005). In a nationally representative sample of children born in 1986, Brooks-Gunn et al (2003) used data from the National Longitudinal Study of Youth-Child Supplement (NLSY) to examine the Black-White gap in school readiness. The authors found an eleven point gap in readiness of children aged four to five years old based on scores from the Peabody Picture Vocabulary Test-Revised (PPVT-R; Dunn, 1981), adjusting for other student and family demographics and risk factors. Using data from the ECLS-B, Hillemeier et al (2011) found that the AOR for lower cognitive scores at 48 months in non-Hispanic (NH) Black children was 1.97 times that of NH White children. The gap was greater for Hispanic (AOR = 2.61) and Native American (AOR = 2.37) children, but no statistically significant difference was observed for Asian children. In both studies, indicators for LBW status were included in multivariate models.

Parents' Age

Studies show mixed results for the relation of maternal and paternal age with school readiness. Increased maternal age was significantly ($p<0.001$) associated with lower kindergarten school readiness scores for reading (β = -0.11), math (β = -0.06), and attitude to learning (β = -0.01) in a study by Fram et al (2012) using data from the Early Childhood Longitudinal Study-Kindergarten Cohort (ECLS-K; USDE, 2000). In a large study of Western Australian kindergartners, children of the youngest mothers ($\leq$ 20 years old at birth) had lower literacy and numeracy skills at kindergarten entry while children of older mothers had higher scores based on the Best Start Kindergarten Assessment (BKSA), a teacher administered statewide assessment (Moore, 2014).

The association of paternal age and early childhood developmental outcomes is less studied. Using ECLS-B data, Mollborn et al (2011) observed that children of teenage fathers (younger than 20) had significantly lower behavior and cognitive scores at age two relative to children of adult fathers, controlling for other characteristics.

Parenting

Parenting relationships with children play an important role in child development. Studies have assessed the impact of different types of parenting skills, behavior, and parent-child relationships on child development (Shonkoff, 2000). Different types of parenting behavior include discipline, teaching, language use, and nurturing. The frequency and use of these behaviors vary by ethnicity and family income (Hill, 2001). Parenting has been estimated to produce a narrowing of the gap in readiness scores by race in the range of 25 to 50 percent (Brooks-Gunn, 2005). For example, children whose parents regularly read to them during their pre-school years perform better on literacy and reading tests once in school (Bus, 1995), particularly in low-income African American families (Britto, 2006). Hill (2001) observed that parenting type had a greater impact on school readiness among low-income and minority families relative to high income and non-minority families. High-quality, center-based programs with a parenting component have been shown to be successful in improving parenting behaviors in the first four years of children's lives (Brooks-Gunn, 2005).

Birth Order, Family Structure, and Other Risk Factors

Other less well documented social and behavioral risk factors associated with school readiness include first birth order (Beaino, 2011; Baker, 2012) particularly for children born to single mothers (Malacova, 2009), singleton birth (Hillemeier, 2011), married parents at birth (Hillemeier, 2011; Fomby, 2011; Isaacs, 2011), stable family structures during early childhood (Janus, 2007; Fomby, 2011), no maternal smoking during pregnancy (Moore, 2014), breastfeeding (Beaino, 2011), and paternal involvement (Black, 1999).

Summary

Despite considerable research on the developmental outcomes of children born premature, gaps persist related to instruments used to measure outcomes. The majority of studies that examined the relation between birth weight, gestational age and early academic performance used a single subtest instrument to measure students' ability on reading, math, or writing (Anderson, 2003; Saigal, 2003; Pritchard, 2009; Taylor, 1998). Moreover, until recently, these assessments have often been conducted among very small samples limiting the range of academic behaviors that are assessed (Keller-Margulis, 2011). When the measure is specifically school readiness, it is often treated as a dichotomous variable, limiting the opportunity to examine the variation and degree of readiness, particularly in at-risk LBW and PTB populations.

Although the tests used in previous studies are all internally and externally valid measures of a child's IQ and academic ability, they are not complete measures of school readiness or school-age abilities. A more complete measure of a child's school readiness should examine the child's development of emotional, social, and physical characteristics in addition to understanding the child's academic abilities (Raver, 2002). Keller-Margulis et al (2011) also note in their review that many studies rarely access school records for an objective confirmation of learning disabilities and service utilization in the school setting.

These traditional methods of examining school age ability have not assessed the full range of concepts important for evaluating early childhood development. Measures of whether children can read, write, spell, and sit are valid measures of ability in early childhood, but they do not capture the full spectrum of a child's early development. Further, previous efforts have focused largely on what vulnerable children cannot do; this approach is important for developing effective early childhood interventions for those in need, but, an equally important focus should be to understand the areas of development in which vulnerable children may excel.

Prior Care Setting

A contributing factor to school readiness and school-age abilities is the type and quality of care received by the child in the year or two before entering kindergarten. In early childcare settings, children learn how to interact and problem solve with children their age as well as with adults. Studies examining the unique impact of early childhood intervention services on school readiness show significant improvements in early academic abilities for children receiving care in quality programs (Burchinal, 1997; Brooks-Gunn, 1994; Barnett, 1995). The amount and extent of developmental delays in the first two to three years of life experienced by children born LBW or PTB point to a need for early intervention to improve school readiness of children with adverse neonatal outcomes.

Effects of early intervention services for LBW children have been modest in prior studies (McCarton, 1995), but recent research indicates that significant large and long-lasting effects on the developmental outcomes of LBW children are achievable through effective interventions (Hill, 2003; McCarton, 1997). An abundance of early education research has shown that early center-based childcare programs are effective in improving students' cognitive abilities and behaviors; their effects are greatest for children from low-income families (Lee, 2014; Forry, 2013; Burchinal, 1997; Fantuzzo, 2005; Ramey, 2004). Further, research shows that children attending some form of high-quality center-based child care develop an understanding of how to communicate with others around them and express their ideas. Much of this effect depends on the quality of the program and the caregiver's interactions with the child (NICHD, 2000; McCartney, 1984).

The Infant Health and Development Program (IHDP) was evaluated in a multisite, randomized, controlled trial of LBW infants born in 1984-1985 followed up to three years of age. The intervention included home visits in the first three years of life and high-quality center-based care in the second and third years (IHDP, 1990). McCarton et al (1997) observed a quarter of a standard deviation intent-to-treat (ITT) effect among heavier LBW (2001 – 2500 g) infants, but no effect for lighter LBW infants ($\leq$2000 g) on WIAT tests of IQ, mathematics achievement, and receptive vocabulary. The ITT methodology does not estimate the per protocol effect of the intervention, which is difficult to estimate because families that follow the protocol are likely different than those who do not.

In a study of approximately 4,000 kindergartners from a large urban US school district, Fantuzzo et al (2005) found that kindergartners from center-based care programs (care provided in a location such as a business or religious program for more than 10 children) had higher mean assessment scores across language arts, mathematics, motor skills, social knowledge, and work habits domains. Although the study accounted for student, family, and neighborhood characteristics, the authors did not evaluate the characteristics of students at birth. The review by Ramey et al (2004) of randomized controlled trials (RCTs) (the Abecedarian Study and Project CARE) found that high-quality preschool programs substantially improve school readiness in high risk populations; but again, the impact of programs for children with specific neonatal characteristics was not described.

Recently, Lee et al (2014) examined the effect of Head Start programs on school readiness using data from the ECLS-B cohort. Students attending a Head Start program had higher early reading and math scores than students attending other nonparental or parental care settings, but lower reading scores than children attending prekindergarten, adjusting for LBW, prematurity at birth and other student and family characteristics. The specific impact on school readiness levels of different care settings by LBW status was not examined.

Fram et al (2012) used the ECLS-K to examine how PK care and experiences mediate the relation between early child care participation and kindergarten entry outcomes, although they did not account for student birth characteristics like LBW or PTB. As the authors note, a major limitation of the ECLS-K is that "measures of child care participation are taken from parent' retrospective self-reports, and there is little and imprecise information on quality characteristics of different child care arrangements or duration of time a child has spent in arrangement". Despite these limitations, the authors found that school readiness scores in reading, math, attitude, self-control and externalizing domains varied significantly by the type of care students received before kindergarten entry, adjusting for other student characteristics.

Forry et al (2013) used statewide Maryland Model for School Readiness (MMSR) data from 2009 and 2010 to explore the relation between different types of subsidized child care, state prekindergarten, and Head Start programs and school readiness. To address concerns about unconfirmed child care, data about child care subsidy and prekindergarten enrollment from the Maryland State Department of Education (MSDE) were linked with the MMSR data. Compared to family child care or informal home care, students entering school after attending some form of subsidized center care were more likely to be rated fully ready to learn on the language and literacy and mathematical thinking domains of the MMSR. Enrollment in state sponsored prekindergarten, but not Head Start, was strongly associated with being academically ready for kindergarten. Again, the authors were only able to control basic student characteristics at school entry (disability status, English language learner status, race, gender, and age) and other family and school characteristics.

A recent study by Chen et al (2014) showed a small moderating effect of preschool on the relation between neonatal characteristics and school readiness. They examined this interactive effect in a nationally representative sample of 8,060 Australian kindergarten students (Chen, 2014). The authors observed that although students born PTB, LBW, and small for gestational age (SGA) had significantly lower cognitive scores, preschool attendance did not significantly moderate the relation between prematurity and school readiness overall. A significant increase in cognitive readiness scores was observed for SGA children who were enrolled in preschool. The ability to detect a moderating preschool attendance effect may have been hindered by the study sample characteristics. While 70% of the study cohort had attended a preschool at some point, only seven and six percent of the students were PTB or LBW, respectively. The authors did not provide an estimate of the percentage of PTB or LBW students who did not attend a preschool program.

The limited studies examining the impact of early childcare on development of LBW children highlights a need for more research. The first few years of a child's life are critical periods when appropriate monitoring, screening, and interventions can have a profound impact on life trajectories of the most vulnerable children. Clarifying which school-age skills are influenced by different care settings is important to developing more effective programs.

Neighborhoods Characteristics

Advances in statistical software and methods has increased the feasibility and use of employing multivariate multilevel models to better understand the social context of development for young children. These advances allow studies to highlight variation in birth outcomes like LBW and PTB accounted for by neighborhood characteristics and other individual-level characteristics (Buka, 2003; Morenoff, 2003; Roberts, 1997; O'Campo, 1997; Pearl, 2001; Gorman, 1999; and Slogget, 1994). For example, Buka et al (2003) observed both an inverse association between neighborhood economic disadvantage and a positive correlation of neighborhood social support with infant birth weight in Chicago between 1994 and 1996, independent of maternal characteristics. Morenoff (2003) showed that the neighborhood level mechanisms associated with stress and adaptation – violent crime and community support via participation in local voluntary associations – were the most robust and consistent predictors of birth weight. O'Campo et al (1997) found that per capita income was directly related to LBW among Baltimore City mothers.

A growing number of studies have examined the social determinants of health in neighborhoods and communities that influence child development independent of student and family characteristics (Lovasi, 2014; Leventhal, 2000; Hanson, 2011; Lapointe, 2007; Shonkoff, 2000; Kershaw, 2007; Nettles, 2008; Malacova, 2009; Carpiano, 2009; Dearing, 2004; Caughy, 2008; Oliver, 2007). In a nationally representative sample of four year old students, Hanson et al (2011) found that neighborhood residence alone – not controlling for other individual level characteristics - explained up to 29% of the variance in academic outcomes, and approximately 15% of the variance of social self-regulating and problem behavior outcomes. Economic hardship, comprised of neighborhood indicators of the percentage of female headed households, percentage of poverty in 1999, and the percentage of male unemployment, was inversely associated only with math and letter knowledge, after adjusting for other child and mother characteristics. A positive adjusted correlation between the percent of English-speaking households at the neighborhood level and child social participation, derived from a factor analysis of the Social Skills Rating System (Gresham, 1990), was also observed.

In a review of studies of neighborhood influences on child development, Nettles et al (2008) concluded that "neighborhood characteristics and processes… serve as moderators, rather than mediators, on parenting effects in school-related outcomes" (p.18). Dearing (2004) examined the moderating effects of neighborhood income and crime on parenting and academic performance among elementary children. They found that among African American children in Boston, restrictive parenting values was negatively associated with academic performance in low-risk neighborhoods. The same values were positively associated with academic performance in high-risk neighborhoods. In a cohort of Baltimore City families recruited into a home visiting program, Caughy et al (2006) observed that home environments "rich in African American culture" were positively associated with cognitive and receptive language skills in first graders. The effect was greater for boys in high-risk neighborhoods as characterized by a negative social climate than in low-risk neighborhoods.

Andreias et al (2010) observed that the percentage of families below the poverty level was inversely associated with academic performance of eight year olds born extremely LBW (<1000 grams) after adjusting for student and maternal characteristics. In Leventhal and Brooks-Gunn's (2000) extensive review of neighborhood effects on child and adolescent outcomes, the authors note that the neighborhood dimensions most important for early child development at the time included neighborhood socio-economic status (SES) and residential stability, with neighborhood SES being the most important.

Exposure to neighborhood level pathogens is a salient risk factor for children growing up in low-income families and neighborhoods where toxic exposure to air pollution, pesticide use, and dilapidated housing is prevalent (Adamkiewicz, 2011; Hutch, 2011; Jackson, 2008). Evidence of an effect of neighborhood environmental pathogens on child development was recently reported by Lovasi et al (2014). In their prospective study of New York City mothers and their offspring, the authors found a significant inverse relation between prenatal exposure to polycyclic aromatic hydrocarbon (PAH) and children's cognitive scores at age five. Indicators of neighborhood building dilapidation and low English proficiency were also associated with lower total, verbal, and performance IQ scores at age five. Neonatal characteristics of the students were not studied.

In summary, child development studies have shown that socio-economic levels and social support in communities are important to foster healthy child development (Maggi, 2010; Duncan, 1999), and may act as a moderator between student and parent characteristics and academic outcomes (Nettles, 2008).

The use of neighborhood level indicators to understand individual level effects on school readiness and early childhood development should not be conducted without understanding the methodological challenges. These challenges include accounting for selection bias of community residents, indirect pathways of neighborhood effects, and measurement error (Duncan, 1998; Sobel, 2001; Winship, 1999). Particularly with administrative data about neighborhood level indicators, disentangling whether changes in school readiness are the result of neighborhood indicators or differential selection of families into certain neighborhoods is difficult. Another major critique of modeling of neighborhood effects is the use of data at one point. In particular, understanding school readiness in the life course perspective means that children are exposed to varying levels of neighborhood indicators over the course of their first five years of life, and these indicators change over time. Data from a single point in time limits the ability to understand how changes in neighborhood characteristics over early childhood influence their development and ultimately their level of school readiness (Sampson, 2002).

This review of the literature on neighborhood level indicators of LBW and early childhood development shows that much of the research occurred in separate fields. Few studies describe the moderating effects of community characteristics on the development and school readiness of children born LBW.

Literature Review Summary: Gaps in the Literature

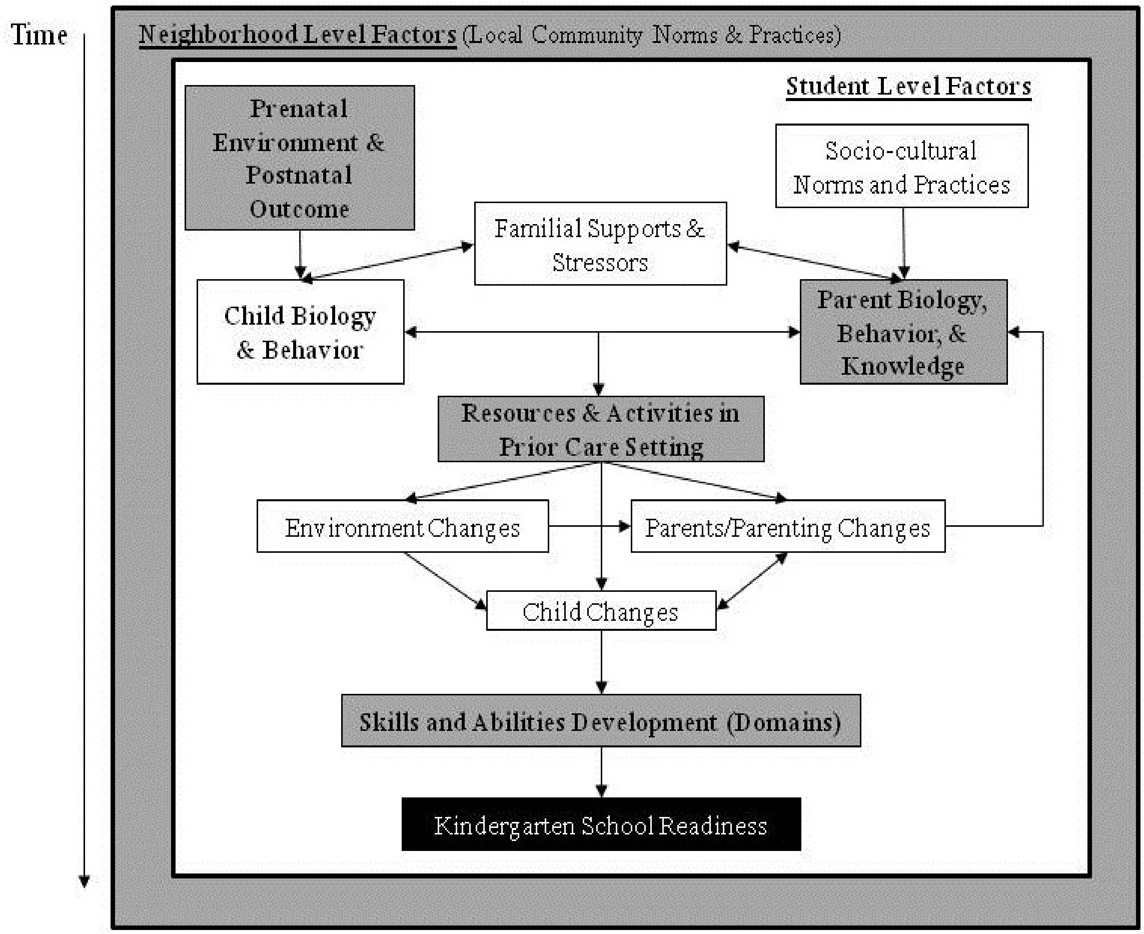
In conclusion, this literature review highlights the following gaps in the research related to school readiness of LBW children, particularly within a large urban setting:

1) Existing studies rely heavily on assessing basic math, reading, and writing skills of school-age children. There is a need to better understand the development of children at school entry using a variety of objective assessments.
2) School readiness is often operationalized as a yes or no variable, despite the understanding that children's developmental growth is constantly changing.
3) There is a need to clarify the impact of early childhood care settings on the developmental trajectories of LBW children, and
4) The role of neighborhood level characteristics in moderating the relation between LBW and school readiness needs further investigation.

Conceptual Framework

The conceptual framework for this study is adapted from the framework of Ramey et al. for intervention programs to increase cognitive development in early childhood (Ramey, 1995 & 1998). This framework conceptualizes the importance of adult-child transactional experiences that occur during the first three years of life. Insufficient exposure to these transactions results in delayed cognitive development; the effects are greatest among children from low socioeconomic families. The framework draws on prior school readiness research which shows that the most important domains of school readiness associated with later performance and behavior are physical well-being and motor development; social and emotional development; approaches to learning; language development; and cognition and general knowledge, including math (Kagan, 1995). Ramey's framework has been modified to include the "complex and interrelated" framework of latent, cumulative, and pathway effects (Maggi, 2010) of life-course factors associated with kindergarten readiness (**Figure 3**).

Figure 3. Kindergarten school readiness conceptual framework, adapted from Ramey et al (1998).



Prior to conception, children are exposed to structural and environmental neighborhood factors that influence the trajectory and outcome of pregnancy, which in turn influence early childhood development of the offspring. Several studies have shown that rates of adverse birth outcomes like LBW and PTB are higher in neighborhoods with high poverty (Kramer, 2008; O'Campo, 2008; Kaufman, 2003; Pearl, 2001; Schempf, 2009) and high levels of environmental pathogens like poor air quality (Lovasi, 2014), high crime (Messer, 2006), and high levels of segregation (Grady, 2006).

These types of neighborhoods are also associated with less availability of quality and effective social services like center-based early childcare and job resources which are important for fostering a healthy pregnancy and, ultimately, a healthy early childhood. The degree to which children are exposed during pregnancy to neighborhood level risk factors is largely dependent on maternal characteristics and behaviors which determine the type of residential structural and environmental exposures incurred during gestation.

The characteristics and settings in which the child begins life play a significant role for whether or not the infant will have the opportunity to develop emotionally, socially, and neurologically to be ready for kindergarten. Studies show that LBW children are more likely to have reading and math disabilities (Breslau, 2001) while PTB have higher rates of math disabilities, Attention Deficit and Hyperactivity Disorder (AD/HD), and executive functioning problems (Baron, 2010). Stanton-Chapman et al. (2004) documented that among low-income Head Start children, the more risk factors present at birth, the lower the likelihood that a child will develop the language abilities to be ready for pre-school.

Early childcare is also where the child has the opportunity to engage in adult-child or child-child interactions which may contribute to or detract from the child's development of school readiness skills, depending on the quality and duration of the interactions (Ramey, 1995; Bronfenbrenner, 1994). As the child develops, parents may recognize and respond to the child's progress and restructure their parenting in order to improve the child's development. This process occurs over the course of a child's first five years, before school begins, within the context of the social norms, environmental, and economic conditions of the child's surrounding home life, neighborhood and community (Hanson, 2011).

In 2002, the Centers for Disease Control and Prevention (CDC) Task Force on Community Preventive Services strongly recommended "publicly funded, center-based, comprehensive early childhood development programs for low-income children aged 3 – 5 years". This recommendation is based on the evidence of the programs' effectiveness in preventing developmental delays (CDC, 2002). In a large urban setting like Baltimore City where barriers to child development such as parents' substance abuse, poor nutrition, poor safety, poor housing, and poor structural environments vary by neighborhood (Ames, 2011), understanding how neighborhood characteristics uniquely impact school readiness is imperative. As recognized by Shonkoff et al (2000), "the dual risk of poverty experienced simultaneously in the family and in the surrounding neighborhood… increases young children's vulnerability to adverse consequences".

The main objective of this dissertation is to understand why students from an urban school district like Baltimore City are not entering kindergarten ready to learn at higher rates. Secondary objectives include: 1) helping to close the gap in knowledge regarding the academic deficits experienced by children (Keller-Margulis, 2011) born with adverse birth outcomes like LBW, 2) describing the differential impact of prior care settings on the relation between neonatal outcomes and school readiness, and 3) documenting the possible moderating effects of local neighborhood conditions on school readiness for LBW children in an urban setting.

The use of secondary data to assess the relation between birth characteristics and school readiness limits the ability to examine several factors presented in the conceptual framework in this study. The highlighted boxes in **Figure 3** indicate the factors that were examined. BCPS and birth certificate data do not include information pertaining to familial supports and stressors, sociocultural norms and practices, parenting or parent's values, and changes in child and parenting behaviors during the child's early developmental years.

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CHAPTER THREE

RESEARCH DESIGN AND METHODS

Overview

This chapter describes the methods of study to address the relation of school readiness with low birth weight (LBW) and preterm birth (PTB) among Baltimore City students and to examine the impact of prior care setting and neighborhood residence on this association. The chapter begins by listing the main study aims followed by a description of the study design and final study sample. A description of the sources of data is provided next, followed by the dependent and independent variables and how they were operationalized for the study. In the final section, the methods pertaining to the analysis of data, including statistical models used to evaluate the study aims are described.

Study Aims

There were three aims of the study reported here:

Aim 1: Determine whether LBW (<2500 grams) and PTB (<37 weeks gestation) are related to school readiness among Baltimore City kindergartners, adjusting for maternal and child characteristics at birth.

Aim 2: To assess whether type of prior care moderates the relation between LBW and PTB and school readiness, after adjusting for other student and maternal characteristics.

Aim 3: To examine whether Baltimore neighborhood characteristics modify the relation between LBW and PTB and school readiness, adjusting for maternal and child characteristics at birth and prior care characteristics at school entry.

Study Design

Data for this dissertation was derived from three existing data sources which were merged for the first time to create a retrospective cohort study of school readiness in Baltimore City. The study population consists of Baltimore City Public School (BCPS) kindergarten students who were rated for school readiness by their teachers using the Maryland Model for School Readiness (MMSR) program for the first time between the fall of 2002 and 2012 and whose mothers resided in Baltimore City at the time of the student's birth. Staff at BCPS's Office of Achievement and Accountability (OAA) created a data file with the names of kindergarten students, their date of birth (DOB), and an anonymized ID for staff at the Maryland Department of Health and Mental Hygiene (MDHMH) Vital Statistics Division to link with birth certificates based on exact matches of the students' first and last name and DOB. OAA staff provided the principal investigator (PI) with a dataset containing de-identified MMSR data with the same anonymized student ID. After the linking process was complete, a dataset containing linked and unlinked selected birth certificate data and anonymized ID's was provided to the PI for linking each anonymized ID to school readiness data for study purposes.

A Memorandum of Understanding (MOU) covering the use of the BCPS data was drafted and signed by BCPS officials and the PI. The study protocol was exempt from Johns Hopkins Institutional Review Board on the grounds that because of the lack of identifiable data for study participants it did not qualify as human subjects research, as defined by the United States Department of Health and Human Services (DHHS) regulations 45 CFR 46.102.

Study Sample

The initial population consisted of 62,822 first time Baltimore city kindergarten students with an MMSR record completed between the fall of 2002 and 2012. The process of linking students to their birth certificates resulted in a match rate of 79.8% (n=50,158). Eighty-three percent (n=41,808) of kindergarten students with linked birth certificates had a Baltimore City census tract listed as the maternal residence at birth. These students were retained for the initial study sample to minimize sample selection bias, as discussed below.

The following exclusion criteria were applied to the initial study sample in order to ensure accurate and valid study results. Excluded records of students included: 586 (1.4%) records with inconsistent gender codes (MMSR data indicated the student was male while birth certificate identified the student as female, and vice versa); thirteen records where birth weight was less than 500 grams, one record with birth weight greater than 6000 grams, and one with missing birth weight information; 840 (2.0%) records with missing gestational age that could not be reconciled by comparing the mothers' date of last menstrual period (LMP) and the newborn's birth weight to determine an estimated gestational age; and 981 (2.4%) records with fewer than 28 completed school readiness assessment items. The birth weight of one male with missing birth weight who was born at 39 weeks gestation was recoded to the mean birth weight for males of the same gestational age in the study sample (3318 grams). These exclusions resulted in the removal of a total of 2,345 (5.6%) students from the sample for analysis.

MMSR procedures recommend composite readiness scores not be calculated where missing items are present in the assessment (MSDE, 2013). One (N = 790; 2.0%)

or two (N = 186; 0.5%) missing assessment items were present for 2.5% of the remaining 39,463 students in the study sample. Scores for these missing items were imputed using hot deck imputation methods (Andridge, 2010). For each item, students with a missing score were randomly assigned the score of a matched student based on characteristics available at school entry[b] for each student. Composite and domain specific readiness scores were then recalculated. This process resulted in a slight decrease of the composite mean readiness score from 73.1 (95% CI: 73.0-73.3) for the sample of 38,486 students with non-missing items to 72.9 (95% CI: 72.8-73.1) in the complete study sample of 39,463 students with imputed values (T-test for the difference of means p-value = 0.0283).

The final study sample (n = 39,463) included 62.8% of students from the initial study population of first time Baltimore City kindergartners between 2002 and 2012 (n = 62,822). Compared to the initial study population, the final sample consisted of kindergartners who were more likely to be free or reduced meal plan students (FARMS), non-English language learners (ELL), non-Hispanic (NH) Black, five years old at school entry (as of September 1st), and to have attended a BCPS district prekindergarten (PK) program. Mean composite readiness scores were significantly higher in the final study sample than the initial population, but only by 0.2 points (**Table 1**). Students excluded from the final study sample were more likely to be Hispanic, non-FARMS, and to have received informal home care in the year prior to entering kindergarten. The larger discrepancy for Hispanic students is likely due to difficulty exactly matching the student's first and last names.

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[b] Students matched using kindergarten cohort year ($\geq$2007 or not), gender, prior care setting, FARMS status, and disability status characteristics.

Table 1. Comparison of initial study population and final study sample characteristics of Baltimore City kindergartners, 2002 to 2012

Characteristic	Study Population	Final Study Sample
	% (N)	% (N)
Total	100.0 (62822)	100.0 (39463)
Female	49.5 (31072)	49.5 (31072)
FARMS	81.6 (51277)	83.4 (32927)*
SWD	7.6 (4756)	7.8 (4756)
ELL	4.5 (2804)	2.7 (1044)*
Student Race/Ethnicity		
NH Black	83.7 (52604)	86.6 (34179)*
NH White	9.9 (6233)	9.4 (3703)*
Hispanic	5.1 (3179)	3.3 (1295)*
Asian	0.9 (561)	0.4 (155)*
Other	0.4 (241)	0.3 (241)
Prior Care Setting		
District PK	46.7 (29325)	49.9 (19693)*
Informal Home Care	25.1 (15784)	22.7 (8973)*
Head Start	11.8 (7415)	12.3 (7415)
Child Care Center	4.9 (3099)	4.6 (3099)
Family Child Care	2.8 (1786)	2.7 (1786)
Private Nursery PK	2.6 (1650)	2.5 (1650)
Other PK	6.0 (3763)	5.3 (2083)*
Student Age†		
Five	90.6 (56944)	91.9 (36270)*
Under Five	8.3 (5195)	7.2 (2854)*
Six and older	1.1 (683)	0.9 (339)*
Composite School Readiness, mean (SD)	72.9 (13.5)	73.1 (13.6)*

NH: non-Hispanic Other includes American Indian/Alaskan Native, Multiple Races, and Native Hawaiian/Other Pacific Islanders
FARMS: free and reduced meals SWD: student with disability ELL: English language learner SD: standard deviation
†Age as of September 1 of the year of the first kindergarten enrollment for each student.
* $p<0.05$

Sources of Data

Baltimore City Public Schools Maryland Model for School Readiness (MMSR)

As mandated by the Maryland State Department of Health, BCPS assess the readiness levels of all students entering kindergarten each school year as part of the Maryland Model for School Readiness (MSDE, 2013). This assessment and instructional system was designed to provide parents, teachers, and early childhood providers with a common understanding of what children know and are able to do upon entering school. MMSR incorporates research-based instruction, age-appropriate assessment of children's learning, and effective communication among teachers, parents, and early childhood providers. All children entering kindergarten in Maryland are assessed by kindergarten teachers for level of mastery across several learning domains that measure the students' school readiness. This assessment is important to children's academic careers because it provides a common goal and language of how parents, teachers, and providers can support young children's learning.

Maryland Department of Health and Mental Hygiene (MDHMH) Birth Certificates

Birth certificate data from the MDHMH for calendar years 1997-2007 were used to link data about students' birth characteristics with kindergarten school readiness data from the MMSR. They include data about the students' health at birth (birth weight, newborn conditions, for example) as well as maternal and paternal information (race, age, years of education, for example) that may be related to students' readiness at school entry. Birth certificate data were based on the 1989 version of the National Standard Certificate of birth. Thus, they were not subject to limitations in variable comparability across years imposed by the introduction of the revised 2003 birth certificate which took place in 2010 in Maryland.

Baltimore Neighborhood Indicators Alliance – Jacob France Institute (BNIA-JFI)

"BNIA-JFI is a nonprofit organization whose core mission is to provide open access to meaningful, reliable, and actionable data about and for the City of Baltimore and its communities. BNIA-JFI builds on and coordinates the related work of citywide nonprofit organizations, city and state government agencies, neighborhoods, foundations, businesses, and universities to support and strengthen the principles and practices of well informed decision making for change toward strong neighborhoods, improved quality of life, and a thriving city"[c]. Their work involves maintaining data collected about community level indicators for all 55 Baltimore metro area neighborhoods between 2000 and 2012. From this open source data repository, neighborhood level estimates of demographic, housing and community development, workforce and economic development, and crime and safety were used to examine factors associated with school readiness.

Dependent Variable

The dependent variable was school readiness, as defined by the MMSR rating system. School readiness was chosen because of its critical importance to early academic performance, educational attainment and subsequent health and health behaviors later in life. Studies show that students who are academically, socially, and emotionally prepared when they begin their early education are more likely to perform better in later grades (Duncan, 2007; LaParo, 2000), have better physical and mental health, and to be

[c] More information about BNIA-JFI can be found here: http://bniajfi.org/about_bnia/

employed (Ross, 1995) than students who are not prepared in early childhood. It is often difficult for individuals who do not begin school ready and prepared to 'catch-up' to their peers academically and socially, creating an avenue for social and behavioral deviance in young adulthood. The impact of school readiness is profound within the life-course perspective.

The MMSR data is unique in that multiple domains of school readiness are evaluated for all kindergartners using the Work Sampling System (WSS). The WSS is a curriculum-embedded instructional assessment program that trains teachers to collect and evaluate student progress throughout the school year. Instead of students completing an end of year assessment test, kindergartners are evaluated based on the totality of work evaluated over time instead of at one point in the year. The WSS consists of three complementary elements: developmental guidelines and checklists, portfolios of students work, and summary reports. Checklists assist and guide teachers in observing and documenting students' growth and progress across seven developmental domains: personal and social, language and literacy, mathematical thinking, scientific thinking, social studies, the arts, and physical development. Portfolios help illustrate student's efforts, progress, and achievements throughout the year. Finally, the summary reports of student's performance are completed 3 times per year. For the purposes of the MMSR, school readiness is defined by the kindergartners' performance on the WSS at the beginning of the school year in November.

A three tiered scoring approach is used for kindergarten teachers to assess each student's readiness level as full, approaching, or still developing on 30 items across the seven domains depicted in **Appendix A** (MSDE, 2013). For each item, a rating of three indicates that the student *consistently* demonstrates the skill, behavior, or knowledge measured, a rating of two indicates the student *inconsistently* demonstrates the skills, and a rating of one means the student *does not demonstrate* the skills.

The language and literacy domain has six items, while the remaining six domains have only four items. Domain specific scores are determined by summing all items within the domain. For the four-item domains, total scores range from 4 to 12 and domain specific readiness levels are determined by dividing the range into thirds. Scores less than or equal to 6 are categorized as developing readiness (DR), 7 to 9 are categorized as approaching readiness (AR), and scores of 10 and above as fully ready (FR). For the six-item domain, language and literacy, scores less than or equal to 9 are categorized as DR, 10 to 14 are categorized as AR, and scores 15 and above, as FR. A composite score of overall school readiness is only calculated if all 30 items are present for the assessment. The range of composite scores is from 30 to 90. A composite score less than 50 is considered DR, 50 -70 is categorized AR, and scores above 70, as FR (MSDE, 2013).

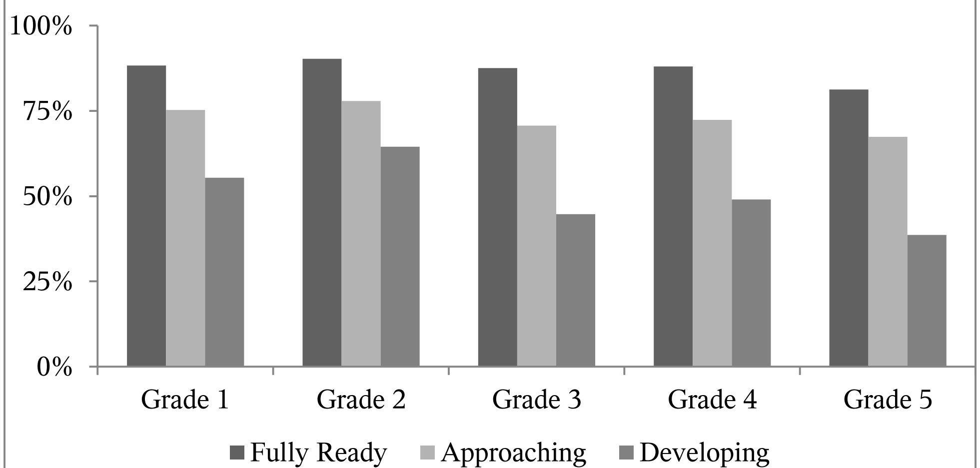
The WSS checklist system for evaluating school readiness is a robust performance-based early childhood assessment tool (Grisham-Brown, 2006; Meisels, 2001; Pyle, 2002) and has been used by multiple states including Arkansas, Kansas, Maryland, Minnesota, and Nebraska (Brown, 2007; Forry, 2013; Ginicola, 2013). An evaluation of the WSS assessment checklist was conducted among 100 children entering kindergarten for the first time in 1991 from 10 different classrooms across three Michigan school districts (Meisels, 1995). The evaluation showed high internal consistency across five domains (Art and fine motor; Movement & gross motor; Concept & number; Language & literacy; and Personal/social development) of the checklist administered in the fall (used by MMSR). Cronbach alpha's ranged from 0.88 to 0.93. Instruments with Cronbach alpha's greater than 0.80 are considered reliable (Nunnally, 1978; Lance, 2006). Strong concurrent validity (total Fall checklist $r = 0.75$) between the WSS checklist and individually administered norm-referenced assessment Woodcock-Johnson Psycho-educational Battery-Revised kindergarten achievement test (Woodcock, 1989) was observed using zero-order correlations.

In the final study sample of the current study, a Cronbach alpha of 0.97 was observed for the entire assessment, 0.89 for the social and personal domain, 0.93 for the language and literacy domain, 0.90 for the mathematical thinking domain, 0.92 for the scientific thinking domain, 0.89 for the social studies domain, 0.93 for the arts domain, and 0.90 for the physical development and health domain.

Teachers are well equipped to provide practical and useful objective ratings of school readiness because their assessments are based on observations made first-hand of students as they respond to varying classroom situations and the demands of school. Parent ratings of their child's school readiness level are generally poorer but research suggests it improves the longer children are in school (Farren, 2008). Studies show that teacher ratings of readiness levels and future academic success are highly robust and aligned with other assessments of academic ability (Farren, 2008; Duncan, 2007; Meisels, 2001; Mashburn, 2005; Claessens, 2006).

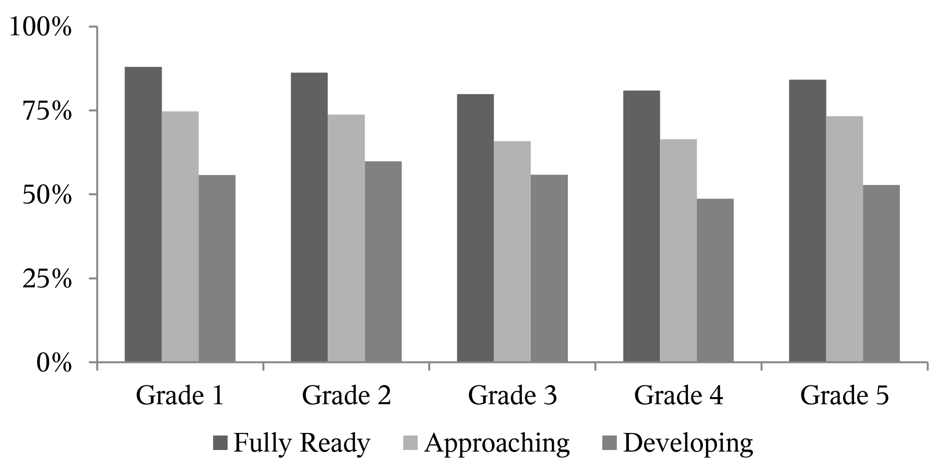
Recent analyses produced by BCPS's OAA showed the importance of school readiness at kindergarten to later academic achievement, confirming the validity of MMSR ratings. The findings show distinctly different pass rates in subsequent norm-referenced math (**Figure 4.1**) and reading (**Figure 4.2**) assessment exams at later grade levels among kindergarten students with fully, approaching, and developing composite readiness scores for the fall 2006 kindergarten cohort (BCPS, 2013).

Figure 4.1 Math performance over time for 2007 Kindergartners: Readiness a factor in test scores, grades 1-5.



Students with an MMSR assessment in SY2007 were linked to their subsequent reading and math scores in grades 1-5. Data includes only promoted students. Note: By grade 5, only 88 Developing students took the MSA from the original cohort; compared to 1,072 of Approaching and 2,138 Fully Ready.

Figure 4.2 Reading performance over time for 2007 Kindergartners: Readiness a factor in test scores, grades 1-5.



Students with an MMSR assessment in SY2007 were linked to their subsequent reading and math scores in grades 1-5. Data includes only promoted students. Note: By grade 5, only 89 Developing students took the MSA from the original cohort; compared to 1,075 of Approaching and 2,136 Fully Ready.

Independent Variables

Main Independent Variables

The main independent variables examined for their relation to school readiness are low birth weight, preterm birth, and the type of care the student received in the twelve months prior to entering school. Descriptions of each variable and how each was operationalized for the study are below.

Low Birth Weight (LBW) was derived from the birth certificate and defined as birth weight less than 2500 grams. Birth weight ranged from 505 grams (1.1 pounds) to 5993 grams (13.2 pounds) in the study sample with a mean of 3095.4 grams (6.8 pounds) and standard deviation of 620.2 grams (1.4 pounds). To examine how different birth weight groups were related to school readiness, three dummy variables were created for different LBW categories relative to the reference group, normal birth weight (NBW; birth weights greater than or equal to 2500 grams). A variable for moderately LBW (MLBW) was defined as '1' for birth weights between 1500 and 2499 grams and '0' otherwise. A dummy variable for very LBW (VLBW) that differed from the typical definition was created where '1' denoted birth weights between 1000 and 1499 grams and '0' otherwise. The third dummy variable represented extremely LBW (ELBW) students where '1' denoted birth weights less than 1000 grams and '0' otherwise. For descriptive purposes, a general LBW category was also created where '1' denoted birth weight less than 2500 grams and '0' for birth weights greater than or equal to 2500 grams (NBW).

Preterm Birth (PTB) was measured using information about the clinical estimate of gestational age (GA) on the birth certificate. Prior to categorizing this variable, however, information for births with questionable data about clinical estimates of GA required validating. To do so, the clinical estimate of gestation was compared to the length of time between the mother's last menstrual period (LMP) and the date of birth. Gender specific intrauterine growth curves detailed by Olsen et al (2010) and an imputation method developed by Taffel et al (1982) were used to validate clinical and LMP estimates of gestation based on the birth weight listed on the birth certificate. This process resulted in recoding GA for 129 (0.33%) records in the final study sample.

The final distribution of GA ranged from 22 to 43 weeks with a mean of 38.3 weeks and a standard deviation of 2.5 weeks. Five dummy variables for GA were created to represent different lengths of pregnancy relative to full-term births (39 – 41 weeks GA). For each dummy variable, '1' denoted the pregnancy length category and '0' otherwise. Variables representing post-term births occurring at 42 or 43 weeks GA, early-term births at 37 or 38 weeks GA, moderately PTB's (MPTB) between 34 and 36 weeks GA, very PTB's (VPTB) between 28 and 33 weeks GA, and extremely PTB's (EPTB) from 22 to 27 weeks GA were created. For descriptive purposes, a general PTB category was also created where '1' was GA less than 37 weeks and '0' for GA from 39 to 41 weeks.

Data about prior care setting was collected by the MMSR assessment from parent's report of the predominant type of early care and education the child received in the 12 months prior to starting kindergarten. Although the assessment documents a variety of settings, the predominant prior care received was grouped into six categories: Head Start, BCPS prekindergarten (district PK), child care center, family child care, non-public nursery school (private nursery PK), home/informal care, and other PK.

Head Start refers to the federal pre-school program for 2 to 5 year olds from low-income families, funded by the US Department of Health and Human Services and licensed by the Maryland State Department of Education (MSDE)/Collaboration and Program Development Branch, and/or local boards of education. *District PK* represents BCPS's prekindergarten education for four-year old children, administered by local boards of education and regulated by the Maryland State Department of Education (MSDE). *Child care center* was defined as care provided in a facility, usually non-residential, for part or all of the day that provides care to children in the absence of the parent. The centers are licensed by the Maryland State Department of Education (MSDE)/Office of Child Care. *Family child care* represents regulated care given to a child younger than 13-years old, in place of parental care for less than 24 hours a day, in a residence other than the child's residence and for which the provider is paid. Family child care is regulated by the Maryland State Department of Education (MSDE)/Office of Child Care. *Private nursery PK* are pre-school programs with an 'education' focus for 3 and 4-year olds; approved or exempted by MSDE; usually part-day, nine months a year. *Home/informal care* indicates care provided by parent(s) or a relative. *Other PK* refers to kindergartners with a parent report of PK enrollment that was not linked to prior student enrollment in a BCPS PK program as determined by OAA staff.

Six dummy variables were created for model inclusion to compare each prior care category to the reference category - district PK. For each dummy variable, '1' denoted the prior care category and '0' otherwise.

Other Independent Variables

In addition to the inclusion of LBW and PTB to describe neonatal morbidity, one and five minute Apgar scores, parity, selected pregnancy-related medical factors, abnormal conditions of the newborn, and complications of labor and/or delivery, were examined from data reported on the birth certificate. Risk factors related to the child's home life and environment at birth were also obtained from the birth certificate. Maternal and paternal race, ethnicity, age and education, marital status, number of siblings, and the presence of paternal data were proxies for the type of family and home environment at birth. Data for paternal characteristics are often underreported on birth certificates (Martin, 2013), but missing data have been shown to be associated with an increased odds of low birth weight and preterm birth (Alio, 2010). Maternal tobacco use was also obtained from the birth certificate and provides context for the condition of the child's birth. Risk factors for school readiness derived from school level information once the child enters school include free and reduced meal plan status (FARMS), academic disability status (SWD), English language learner status (ELL), and the student's age as of September 1 of their school entry year. **Table 2** provides a detailed description of the study variables.

Table 2. Independent variables by category in the analysis of school readiness among Baltimore City kindergarten students, 2002 to 2012

Category	Variable	Values
Main independent variables		
Birth weight	LBW	1: <2500 grams, 0 otherwise
	Moderately LBW	1: 1500-2499 grams, 0 otherwise
	Very LBW	1: 1000-1499 grams, 0 otherwise
	Extremely LBW	1: <1000 grams, 0 otherwise
	Normal birth weight (NBW)	≥2500 grams (reference)
Gestational Age	Post-term	1: 42+ weeks, 0 otherwise
	Early-term	1: 37-38 weeks, 0 otherwise
	PTB	1: <37 weeks, 0 otherwise
	Moderately PTB	1: 34-36 weeks, 0 otherwise
	Very PTB	1: 28-33 weeks, 0 otherwise
	Extremely PTB	1: < 28 weeks, 0 otherwise
	Full-term	39-41 weeks (reference)
Prior Care Setting	Informal home care	1: Informal home care, 0 otherwise
	Head Start	1: Head Start, 0 otherwise
	Child care center	1: Child care center, 0 otherwise
	Family child care	1: Family child care, 0 otherwise
	Private nursery PK	1: Private nursery PK, 0 otherwise
	Other PK	1: Other PK, 0 otherwise
	District PK	(reference)
Student characteristics at school entry		
Gender	Gender	1: Female, 0: Male
ELL	ELL	1: Yes, 0: No
FARMS	FARMS	1: Yes, 0: No
Disability status	Disability status	1: SWD, 0 otherwise
	Missing	1: Missing, 0 otherwise
	General education (non-SWD)	(reference)
Age at school entry	Young	1: Less than five, 0 otherwise
	Older	1: Six and older, 0 otherwise
	Five	(reference)
Race/Ethnicity	NH White	1: NH White, 0 otherwise
	Hispanic	1: Hispanic, 0 otherwise
	Asian	1: Asian, 0 otherwise
	Other	1: Other, 0 otherwise
	NH Black	(reference)
K Cohort	K Cohort Year	1: Before 2007, 0: 2007 to 2013
Student characteristics at birth		

Number of siblings	One	1: One, 0 otherwise
	Two or more	1: Two or more, 0 otherwise
	None	(reference)
Plurality	Multiple birth	1: Multiple, 0: Singleton
Abnormal conditions of the newborn	# Conditions‡	Continuous
	Assisted Ventilation	1: Yes, 0: No
	Anemia	1: Yes, 0: No
Complications of labor and/or delivery	# Complications‡‡	Continuous
	Fetal distress	1: Yes, 0: No
	Placenta previa	1: Yes, 0: No
	Breech/mal-presentation	1: Yes, 0: No
One-minute Apgar scores	Low score	1: Low (< 7), 0 otherwise
	Missing	1: Missing, 0 otherwise
	High score	7-10 (reference)
Five-minute Apgar scores	Low score	1: Low (< 7), 0 otherwise
	Missing	1: Missing, 0 otherwise
	High score	7-10 (reference)
<u>Parent characteristics at birth</u>		
Maternal or Paternal race/ethnicity	NH White	1: NH White, 0 otherwise
	Hispanic	1: Hispanic, 0 otherwise
	Asian	1: Asian, 0 otherwise
	Other	1: Other, 0 otherwise
	Missing	1: Missing, 0 otherwise
	NH Black	(reference)
Maternal birth place	Foreign born	1: Foreign born, 0: US born
Maternal age	Young	1: <20, 0 otherwise
	Older	1: 36 and older, 0 otherwise
	Missing	1: Missing, 0 otherwise
	20 to 35	(reference)
Maternal years of education	Less than 12 years	1: <12 years, 0 otherwise
	12 years	1: 12 years, 0 otherwise
	13+ years	(reference)
Marital status	Married	1: Married, 0: Not married
Maternal tobacco use	Tobacco use	1: Yes, 0 otherwise
	Missing	1: Missing, 0 otherwise
	No tobacco use	(reference)
Pregnancy related medical factors	# Medical factors‡‡‡	Continuous
	Anemia	1: Yes, 0: No
	Gestational diabetes	1: Yes, 0: No
	Eclampsia	1: Yes, 0: No

	Previous PTB	1: Yes, 0: No
Paternal race/ethnicity	NH White	1: NH White, 0 otherwise
	Hispanic	1: Hispanic, 0 otherwise
	Asian	1: Asian, 0 otherwise
	Other	1: Other, 0 otherwise
	Missing	1: Missing, 0 otherwise
	NH Black	(reference)
Paternal data on birth certificate§	Absent	1: Absent, 0: Presence
<u>Neighborhood indicators</u>		
Female headed households	% Female headed households, '10	Continuous
Household income	Median household income, '00 & '10	Continuous
Unemployment	Unemployment rate, '00 & '12	Continuous
Poverty	% Families living below poverty line, '00 & '12	Continuous
Education	% high school diploma, '00 & '12	Continuous
Nutrition	Healthy food availability index, ‘12	Continuous

NH: non-Hispanic † includes American Indian/Alaskan Native, Native Hawaiian/Other Pacific Islander, and Multiple Race §Missing paternal indicators of educational attainment, age, and birth place

‡ Abnormal conditions include: anemia, birth injury, fetal alcohol syndrome, hyaline membrane disease, meconium aspiration syndrome, assisted ventilation (<30 min and >30 min), seizures, and other.

‡‡ Labor complications include: febrile, meconium, premature rupture of membrane, abruptio placenta, placenta previa, other excessive bleeding, seizures during labor, prolonged labor, dysfunctional labor, breech/mal-presentation, cephalopelvic disproportion, cord prolapse, anesthetic complications, fetal distress, and other.

‡‡‡ Medical factors include: anemia, cardiac disease, lung disease, diabetes, genital herpes, hydramnios/oligohydramnios, hemoglobinopathy, hypertension, eclampsia, incompetent cervix, previous infant 4000+ grams, previous preterm infant, renal disease, rh sensitization, uterine bleeding, and other.

Other Student Characteristics

Variables used to measure student characteristics are detailed below. These variables were considered covariates in the analyses.

Student race/ethnicity, as defined by kindergarten assessment data, was constructed to estimate the difference in readiness scores between race and ethnicity groups. Four dummy variables were created: non-Hispanic (NH) White, Hispanic, NH Asian, and NH Other (American Indian/Alaskan Native, Native Hawaiian/Other Pacific Islander, and Multiple Race), NH Black was the reference group. For each dummy variable, '1' denoted the above race/ethnicity groups and '0' otherwise. NH Black students was selected as the reference group because the vast majority (86.6%) of students identified with this group. Five of the six students (0.02%) with missing race/ethnicity values were recoded to NH Black because both parents shared this race category, and the other student with race/ethnicity missing was recoded to NH White because both parents shared this race category.

Student gender was categorized as female ('1') versus male ('0').

Student age was calculated by BCPS OAA staff and is based on the time between the students' date of birth and September 1st of the school year at first time kindergarten entry into BCPS. Age at school entry ranged from 47 to 94 months with a mean age of 64.5 and standard deviation of 3.8 months; sixteen students (0.04%) were 84 months or older. Two dummy variables were created to represent the at risk age categories of younger than five (60 months) and six or older (72+ months) with five year olds representing the reference group. For each variable '1' represented the age risk category and '0' otherwise.

Number of siblings, defined as the number of siblings now living at the students' birth, was derived from the number of 'live births now living' item on the birth certificate. Number of siblings ranged from 0 to 13 with a mean of 1.2 siblings and a standard deviation of 1.4. This information was missing for 135 (0.3%) of the study sample. The number of living siblings was categorized as three dummy variables representing those with one, two or more, or missing information relative to no siblings alive at birth. For each variable, '1' represented the aforementioned sibling category and '0' otherwise.

Plurality was dichotomized as multiple birth ('1'; includes twin, triplet, quadruplet, quintuplet, or sextuplet or more) versus singleton birth ('0') as indicated by 'plurality' on the birth certificate.

Apgar scores at one and five minutes post-birth reported on the students' birth certificates were used to examine the neonatal health of the student. For descriptive purposes, these scores were combined to indicate students who had low (<7) one or five minute Apgar scores ('1') and those who did not ('0'). This was done because no significant difference in mean composite readiness scores of students with low one and five minute Apgar scores was observed ($p=0.1574$). For multivariate models, four dummy variables were created to indicate a low (<7) one or five minute Apgar score and missing values for each. The reference category for each indicator was a high one or five minute Apgar score (7+), respectively.

Abnormal conditions of the newborn reported on students' birth certificates were used to categorize newborn abnormalities. Assisted ventilation before 30 minutes post-birth and assisted ventilation after 30 minutes post-birth were combined so that '1' indicated report of assisted ventilation at any time post-birth and '0', no report. An indicator for whether anemia was reported on the birth certificate was created where '1' represents report of anemia and '0', no anemia. Staff at MDHMH also created an indicator of the total number of abnormal conditions present at birth; this variable was treated as continuous and ranged from 0 to 4 with a mean of 0.05 abnormalities and standard deviation of 0.24.

Complications of labor and/or delivery, including placenta previa, breech/mal-presentation, and fetal distress, were selected from the birth certificate and dichotomized to indicate either the presence ('1') or absence ('0') of the complication on the student's birth certificate. Staff at MDHMH created an indicator of the total number of complications present at birth; this variable was treated as continuous and ranged from 0 to 6 with a mean of 0.4 complications and standard deviation of 0.64.

English language learner (ELL) status was determined by BCPS at student enrollment. For analyses, this indicator was dichotomized so that '1' denoted ELL status and '0', non-ELL status (reference group). Fifteen (0.04%) students with missing ELL status values were recoded to non-ELL because more than 95% of BCPS enrolled students are non-ELL students.

Free and reduced meal plan (FARMS) status is determined by BCPS at enrollment. This indicator represents students from families meeting the household specific income eligibility guidelines[d] set by the US Department of Agriculture to receive either free or reduced price meals while enrolled in the district. According to MSDE reports, BCPS has the highest ratio of free to reduced price student enrollment of all Maryland school districts. Free meal students made up two-thirds to three-quarters of official school year

[d] See BCPS's Free Meal Program website at http://www.baltimorecityschools.org/Page/25305

enrollment in BCPS and more than 90% of all FARMS students during the study period[e]. This variable was measured as dichotomous; '1' denoted non-FARMS status and '0', FARMS status (reference group). Thirteen students (0.03%) with missing FARMS values were recoded to FARMS status because the large majority of BCPS enrolled students are FARMS students.

Disability status was determined by BCPS. By law, students with disabilities (SWD) are entitled to a free, appropriate public education from birth to age 21. Students determined to have some form of disability are enrolled into an individualized education program (IEP) to help facilitate successful learning throughout their academic career. BCPS's SWD enrollment rate (14.3%) ranked fourth highest among Maryland elementary schools in 2007 and in 2013 with an enrollment percentage of 13.7%[f]. More than three percent (n = 1,284) of students had missing disability status codes. Two dummy variables were created to examine differences in readiness scores for SWD and students with missing values relative to non-SWD (general education) students. Each variable was constructed so that '1' denoted SWD or missing disability status and '0' otherwise.

Parent Characteristics

Maternal and paternal race/ethnicity was based on information reported on the students' birth certificate. Using a combination of the 'Hispanic origin' and 'race' indicators, racial groupings were created to mimic the student race/ethnicity indicator described above. Four dummy variables were created to represent the race/ethnicity of the students'

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[e] Source: MSDE Free and Reduced-Price Meal Data. Available at: http://www.marylandpublicschools.org/msde/programs/schoolnutrition/docs/Free+and+Reduced-Price+Meal+Data.html

[f] Source: MDReportCard data downloads. Available at: http://mdreportcard.org/downloadindex.aspx?K=99AAAA

parents with NH Black as the reference group. For NH White, Hispanic, NH Asian (Chinese or Japanese), NH Other race (American Indian, Hawaiian, Filipino, and Other Asian/Pacific Islander), and those with missing race, a dummy indicator was created where '1' represented one of these categories and '0' otherwise.

Maternal and paternal age was obtained from the students' birth certificate. Maternal age at birth ranged from 12 to 50 with a mean of 24.3 years, standard deviation of 6.2 years, and median of 23. Paternal age ranged from 11 to 70 with a mean of 27.6 years, standard deviation of 7.7 years, and median of 26. Two dummy variables were created for kindergartners of teenage (< 20 years) and older (> 35 years) parents compared to parents aged 20 to 35 years old at birth (reference group). For each, '1' indicated the non-reference age group and '0' otherwise. Dummy variables for missing maternal and paternal age were also created.

Maternal and paternal years of education was used to examine whether mean school readiness scores of kindergartners whose parents had less than 12 years of education or parents with 12 years of education were different from students of parents with 13 or more years of education at birth (reference group). For both parents and each indicator '1' defined the non-reference years of education category and '0' otherwise. Dummy variables for missing maternal and paternal years of education were also created.

Paternal data missing on birth certificate was created as a proxy measure of paternal involvement. Paternal years of education, age, and birth place were missing for 40.4%, 29.5%, and 32.5% of the final study sample, respectively. To account for the presence of information, a missing paternal information dichotomous indicator was created where '1' indicated no paternal education, age, or birth place information and ‘0’, the presence of at least one of these paternal characteristics on the birth certificate (reference group).

Marital status is reported on the birth certificate as married or not at the time of the students’ birth, and treated for the analysis where ‘1’ represented that the parents were married and ‘0’, single parents at the time of birth (reference group).

Maternal birth place was derived from the birth certificate. Mother’s born in all fifty states, the District of Columbia, Puerto Rico, Virgin Islands, and Guam represented US born mothers, the reference group. Two hundred and seventy-six students (0.7%) had missing birth place data. Two dummy variables were used for maternal birth place. For each variable ‘1’ represented either foreign born mothers (Canada, Cuba, Mexico, other western hemisphere, or remainder of world) or missing birth place and ‘0’ otherwise.

Maternal tobacco use, obtained from the birth certificate, is an indication of whether the mother used tobacco during pregnancy. Due to missing values (0.7%) two dummy variables were created where ‘1’ represented tobacco use during or missing value and ‘0’ otherwise.

Maternal pregnancy related medical factors included anemia, maternal diabetes, eclampsia and previous PTB from the birth certificate. Each was treated as an individual dichotomous indicator of the presence (‘1’) or absence (‘0’) of the medical factor. Staff at MDHMH created an indicator of the total number of medical factors present at birth for each mother; this variable was treated as a continuous variable and ranged from 0 to 5 with mean of 0.37 medical factors and standard deviation of 0.65.

Neighborhood Characteristics

Information about the census tract of the mother's residence on students' birth certificates was used to link students to publicly available Baltimore City neighborhood data from BNIA[g]. Some alterations were needed to some neighborhoods due to changes in neighborhood configurations between the 2000 and 2010 BNIA neighborhood profiles. Data from the 2000 configuration for the 'Jonestown/Oldtown' neighborhood was linked with the 2010 configuration of the 'Harbor East/Little Italy' neighborhood, and data from the 2000 configuration for the 'Perkins/Middle East' neighborhood was linked to the 2010 configuration of the 'Oldtown/Middle East' neighborhood.

Neighborhood characteristics have been shown to be influential in early childhood development, education, and health (Oliver, 2007; Andreias, 2009; Nettles, 2008). Hundreds of individual neighborhood level indicators were available through BNIA spanning multiple years requiring decisions about the best indicators to select for further study. Neighborhood measures related to income and socio-economic status (SES) were selected based on their theoretical and empirical importance to school readiness as identified by recent literature (Oliver, 2007; Andreias, 2009; Carpiano, 2009). Building on the findings from these studies, several indicators were obtained from BNIA as potential characteristics associated with school readiness.

<u>Median household income</u> from 2000 and 2010 was used to account for potential changes over time. Each measure was treated as a continuous variable and interpreted in $1,000 increments.

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[g] More information regarding BNIA indicators can be found here: http://bniajfi.org/vs/vital_signs

Poverty was assessed in 2012 using the percent of households living below the federal poverty line and in 2000 with the percent of married couple families with children earning below the Maryland wage standard; this income cut-off was higher than federal poverty guidelines. Both measures were treated as continuous indicators. BNIA neighborhood data did not contain estimates of the percentage of households living below the federal poverty line in 2000.

Unemployment rates from 2000 and 2010 US Census reports were used to represent the rate of people aged 16-64 who were unemployed and actively looking for work per 1,000 residents. Both measures were treated as continuous variables.

Female headed household was chosen as a proxy for the type of family structure prevalent in the child's neighborhood. This measure represents the percentage of all households with children under 18 in a given neighborhood that were headed by a female as reported by the 2010 US census, and was treated as a continuous variable.

Neighborhood education level was measured by the percent of the population (25 years and over) with some college or bachelor's degree or higher according to 2000 and 2010 US census data.

Healthy food availability index (HFAI) was included as a proxy measure of food insecurity and neighborhood socio-economic status (SES). The HFAI measures the availability of healthy foods in Baltimore food stores using the Nutrition Environment Measurement Survey in Stores (values range from 0 to 27 with higher scores indicating greater availability of healthy foods; Glanz, 2007). Franco et al 2008 adapted the index to measure the availability of healthy food in Baltimore City and Baltimore County in 2006 and found a lower availability of healthy foods in predominantly Black and lower-income neighborhoods compared to white and higher-income neighborhoods. This variable was treated as a continuous indicator.

With only 55 neighborhoods, the number of indicators that could be included in regression models was limited. Therefore, the most parsimonious set of indicators was carefully selected by examining co-linearity among neighborhood indicators.

Data Analysis

Analysis of data to address the study aims was conducted in several steps. First, the dependent and independent variables were explored through tabulation of the variable distributions, means, and variances. Graphs including scatterplots, histograms, and boxplots helped visualize the data and identify outliers. Missing values for school readiness were imputed for students with missing values on one or two items of the assessment only. Students with missing values for the main predictors of interest, birth weight and gestational age, were excluded if their data could not be systematically imputed or recoded. Other missing values were noted in further analyses as dummy variables, where appropriate. Cronbach alpha statistics determined the reliability of the instrument used to measure school readiness in the final study sample.

Colinearity between the independent variables in multivariate models can influence and bias parameter estimates and standard errors (Shieh YY, 2003). Pearson correlation matrices were used to assess colinearity among the study variables. Variables with pair-wise correlations greater than absolute 0.60 ($|r| > 0.60$) were considered for removal to reduce multicolinearity from multivariate regression models (Dormann CF, 2013).

Across student independent variables, only birth weight and gestational age categories were highly correlated; these variables were left in the analysis because they are the two main independent variables of interest (**Appendix B**). Little to no correlation was observed between PTB or LBW categories and prior care settings. The only other moderately strong pair-wise correlation was observed between LBW status and multiple birth ($r = 0.29$; $p < 0.01$) suggesting that multiple birth was positively associated with LBW status. Both variables were retained because the magnitude of the correlation was not large enough to warrant removal of either variable.

One of the strongest parent pair-wise independent variable correlations ($r = 0.58$; $p < 0.01$) was observed between foreign born and Hispanic mothers which is somewhat expected (**Appendix C**). Interestingly, Hispanic fathers were highly, positively correlated with missing paternal data ($r = 0.71$; $p < 0.01$) while non-Hispanic (NH) Black fathers were negatively correlated with missing paternal data ($r = -0.60$; $p < 0.01$). Both variables were examined further because they measure two different constructs. Maternal years of education was positively correlated with paternal years of education ($r = 0.57$; $p < 0.01$), as expected. Paternal education was not examined further because the missing paternal information variable serves as a proxy for paternal involvement. Similarly with maternal and paternal age, a high correlation was observed ($r = 0.75$; $p < 0.01$) and only maternal age was considered for further analyses. Other moderately correlated parent variables included a positive correlation between NH Black mothers and un-married status at birth ($r = 0.27$; $p < 0.01$) and NH White mothers and tobacco use during pregnancy ($r = 0.14$; $p < 0.01$). No other parent variable correlations were strong enough to consider variable removal.

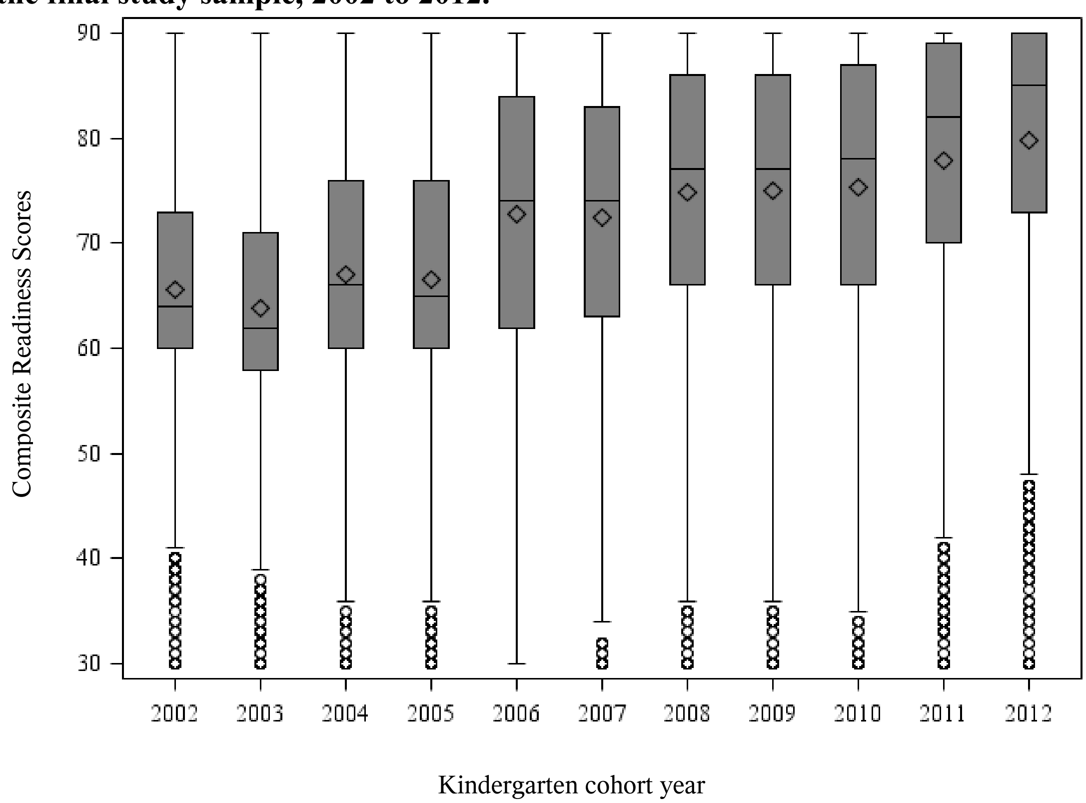
The correlation between neighborhood level independent variables was examined across each of the 55 Baltimore neighborhoods (**Appendix D**). Nearly all variables were at least moderately correlated except for the healthy food availability index (HFAI) which was not highly correlated with other neighborhood variables. As expected, median household income was inversely related to the percentage of the population with a high school diploma or unemployed, and the poverty rate. Poverty was moderately correlated with high school diploma percentages. After assessing the colinearity of each potential indicator and considering prior studies of neighborhood indicators, estimates of median household income, the HFAI, and the percentage of female headed households were selected for further neighborhood analyses. To help characterize the distribution of students in different neighborhood income levels, a neighborhood income categorical variable was created by dividing the product of each neighborhood's 2000 and 2010 median household income into tertiles to represent low, medium, and high income neighborhoods.

Exploration of the data highlighted significant characteristics that influenced the structure of multivariate regression models for the current study. School readiness levels generally increased in Maryland and in BCPS since the start of assessments in the fall of 2001. The boxplot in **Figure 5** shows that indeed the mean composite school readiness scores in the final study sample increased each year from the fall of 2002 to 2012. Results of a bivariate analysis of variance (ANOVA) confirmed that greater variation in composite school readiness scores existed between kindergarten cohort years than within kindergarten cohort years (F statistic = 5752.16; $p < 0.0001$). Similarly, the variation in student readiness scores was greater between schools than within (F statistic = 99.1; p <

0.0001), and between neighborhoods than within (F statistics = 52.9; $p < 0.0001$). Additionally, student readiness scores increased significantly from 66.6 (95% CI: 66.2 - 67.0) in fall 2005 to 72.7 (95% CI: 72.3 – 73.2) in the fall of 2006 after which levels were maintained.

These findings suggest that student school readiness scores were clustered within kindergarten cohort years, entry schools, and neighborhoods, and that not appropriately controlling for these underlying characteristics of the data may lead to biased results. To account for these clusters, multivariate hierarchical linear regression models were used to examine each aim. A linear spline term with '1' indicating kindergartners in cohort years 2002 to 2005 and '0' representing kindergartners in cohort years 2006 to 2012 (reference group) was included as a student level predictor in each model.

Figure 5. Composite school readiness score boxplots by kindergarten cohort year in the final study sample, 2002 to 2012.



All analyses were performed using SAS version 9.4 (SAS, 2012). The methods used to examine each aim of the study were undertaken sequentially such that information gleaned from each aim is used in the subsequent aim. A detailed discussion of the analyses for each aim follows.

Aims 1 & 2: *To determine whether LBW and PTB are related to school readiness among Baltimore City kindergartners, and assess whether type of prior care moderates the relation between LBW and PTB students, adjusting for student and parent characteristics.*

In **Aims 1 and 2**, school readiness scores were treated as continuous outcomes. Specifically, **Aim 1** explored the relation between PTB and LBW and school readiness scores adjusting for other student and parent confounding characteristics. **Aim 2** builds on **Aim 1** by determining whether prior care type significantly modifies the relation between student birth weight and gestational age and school readiness adjusted for other confounders. The confounding effect of prior care on birth weight, gestational age, and school readiness was examined through bivariate analysis. Effect modification by prior care was evidenced by a significant change in the difference in mean school readiness scores of LBW and PTB students compared to NBW and full-term students, respectively, adjusted for other confounders when the type of prior care was considered in the model.

Initially, bivariate relations between composite school readiness scores and student and parent independent variables from the birth certificate were examined through scatterplots, T-tests for continuous and dichotomous variables, and analyses of variance (ANOVA) for categorical variables. Similarly, in order to confirm whether an independent variable was a significant confounder ($p < 0.10$), unadjusted bivariate associations between PTB and LBW and other independent variables were examined. Based on these analyses, student characteristics included race, gender, age at school entry, FARMS status, SWD status, number of siblings living at birth, multiple birth, neonatal assisted ventilation, low one or five minute Apgar scores, fetal distress during labor, and newborn anemia. Parent characteristics were maternal and paternal race, maternal age, maternal years of education, maternal tobacco use, marital status, missing paternal information on the birth certificate, maternal report of a previous PTB, and maternal nativity.

Hierarchical linear multivariate regression models (HLM) were used in the analysis of these two aims. Random intercepts for cohort years and schools were included in each HLM to account for the clustering of student readiness scores within cohort years and schools. The following table shows the steps of the regression analysis for both **Aims 1 and 2**.

The relation between each independent variable and school readiness was first examined in a regression model that accounted for the clustering observed in the data. Model 0, or the empty model, represented the baseline model with which subsequent model results were compared. This model contained random intercepts for student cohort years and schools to account for the clustering of readiness scores within kindergarten cohort years and schools, and a cohort year of school entry indicator (before or after the fall of 2006). Unadjusted coefficients for each variable were generated from this model.

Model 1 added PTB and LBW to examine the amount of variation in school readiness scores explained by PTB and LBW together. To examine the amount of variation in readiness scores explained by student and parent variables alone, separate regression models were constructed that included each of the significant student (model 1a) or parent (model 1b) variables. In model 2, the type of prior care was added to estimate its impact on the relation of PTB and LBW with school readiness, unadjusted for other student and parent characteristics. Model 3 removed prior care setting but added other student confounders to model 2 to document the additional amount of variation in readiness scores explained by other student characteristics. Model 4 added the significant parent confounder characteristics and statistically significant ($p < 0.05$) student characteristics from model 3. Model 5 added the type of prior care received by the student in order to estimate prior care impact. Model 5 also included the student and parent characteristics that were statistically significant from model 4.

Model 6, the full model, included all model 5 variables as well as significant interactions terms for LBW, PTB and type of prior care and other relevant interaction terms based on prior school readiness research. The degree to which each model fit the data was evaluated with covariance parameter estimates and Akaike Information Criterion (AIC) values (Akaike, 1974); the lower the AIC value, the better the model fits the underlying data.

Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Main independent variables (PTB and LBW)	X	X	X	X	X	X
Other student variables			X	X	X	X
Parent variables				X	X	X
Prior care setting		X			X	X
Interaction terms						X

Results from model 4 above were used to evaluate **Aims 1 and 2**, and the full model notation is described in the following:

$$Y_{ijk} = \beta_0 + \beta_1(\textit{cohort year spline})_{ijk} + \beta_2(\textit{PTB})_{ijk} + \beta_3(\textit{LBW})_{ijk} + \beta_4(\textit{Prior Care})_{ijk} +$$
$$B_k(\textit{student and parent characteristics})_{ijk} + \varepsilon_{ijk}$$

Where,

- Y_{ijk} represents the mean readiness score for the i^{th} kindergartner of the j^{th} cohort year at the k^{th} school.
- β_0 is the estimated mean readiness score of the i^{th} kindergartner of the j^{th} cohort year at the k^{th} school when all other variables are equal to zero.
- $\beta_1(\textit{Cohort year spline})_{ijk}$ is the estimated change in mean readiness score comparing kindergarten students entering school in fall 2005 and earlier to kindergarten students entering school in fall 2006 and later, adjusting for other model variables.
- $B_2(\textit{PTB})_{ijk}$ is the estimated change in mean readiness score comparing kindergartners in PTB categories to full term kindergartners, holding all other risk factors are constant.
- $B_3(\textit{LBW})_{ijk}$ is the estimated change in mean readiness score comparing kindergartners in LBW categories to normal birth weight kindergartners, adjusting for all other risk factors.
- $B_4(\textit{Prior Care})_{ijk}$ is the estimated change in mean readiness score comparing kindergartners who did not enroll in each non-district PK program to those who did enroll in a district PK program (reference group) prior to kindergarten, given all other risk factors are held constant.

- $\boldsymbol{\beta_k}$***(student and parent characteristics)***$_{\boldsymbol{ijk}}$ is the estimated change in mean readiness score for each independent variable comparing kindergartners with the selected variable to those without, holding all other characteristics constant. These variables were selected through descriptive and exploratory bivariate analyses explained above to determine which set of variables were statistically significant confounders associated with the outcome and the main independent variables (PTB and LBW).
- $\varepsilon_{ijk} \sim N(0, \sigma^2)$

PTB and LBW were deemed to be associated with school readiness if at least one of the dummy variable categories for each variable was found to be statistically significant ($p < 0.05$) after adjusting for all other confounders (**Aim 1**). To determine whether school readiness scores of PTB and LBW children varied by prior care type, interaction terms between each dummy variable for PTB, LBW, and the type of prior care were entered into model 6. If at least one of the interaction terms was statistically significant ($p < 0.01$) then this was evidence of prior care setting effect modification (**Aim 2**).

To account for the varying domain score ranges, standardized domain readiness scores were created to compare scores within and across domains on a similar scale. Domain readiness scores were standardized to a mean of zero and standard deviation of one within each kindergarten cohort year. Standardized scores represented the number of standard deviations above or below the cohort year mean of the students' score. These scores were used to examine differences in domain readiness scores by PTB and LBW, adjusting for variables included in model 5 plus significant interaction terms ($p<0.001$).

Adjusted parameter estimates and 95% confidence intervals of each PTB and LBW category was examined to identify significant differences in mean domain readiness scores between LBW and NBW or PTB and full-term kindergartners, as well as across readiness domains.

The distribution of composite readiness scores was left skewed such that the majority of readiness scores were above average. To assess the potential bias introduced by estimating a linear regression on these non-normal readiness data, a sensitivity analysis was conducted. Model 5 covariates were included in a generalized estimating equation (GEE) to estimate the log-odds of students being scored as not fully ready (<60 points) for school at school entry. A cut of 60 was chosen as a conservative estimate of non-readiness because, as previously stated, readiness scores changed substantially across years, but the readiness cut-points did not. The model notation is:

$$P(Y)_{ijk} = \beta_0 + \beta_1(\textit{cohort year spline})_{ijk} + \beta_2(\textit{PTB})_{ijk} + \beta_3(\textit{LBW})_{ijk} + \beta_4(\textit{Prior Care})_{ijk} + B_k(\textit{student and parent characteristics})_{ijk} + \varepsilon_{ijk}$$

Where,

- $\boldsymbol{P(Y)_{ijk}}$ represents the probability of the i^{th} kindergartner of the j^{th} cohort year at the k^{th} school being rated not fully ready for school.
- $\boldsymbol{\beta_0}$ is the estimated log-odds of a note fully ready assessment for the i^{th} kindergartner of the j^{th} cohort year at the k^{th} school when all other variables are equal to zero.
- $\boldsymbol{\beta_1(\textit{Cohort year spline})_{ijk}}$ is the estimated change in log-odds of not being fully ready for school comparing kindergarten students entering school in fall 2005 and earlier to kindergarten students entering school in fall 2006 and later, adjusting for other model variables.

- ***B_2(PTB)$_{ijk}$*** is the estimated change in log-odds of not being fully ready for school comparing kindergartners in PTB categories to full term kindergartners, holding all other risk factors are constant.
- ***B_3(LBW)$_{ijk}$*** is the estimated change in log-odds of not being fully ready for school comparing kindergartners in LBW categories to normal birth weight kindergartners, adjusting for all other risk factors.
- ***B_4(Prior Care)$_{ijk}$*** is the estimated change in log-odds of not being fully ready for school comparing kindergartners who did not enroll in each non-district PK program to those who did enroll in a district PK program (reference group) prior to kindergarten, given all other risk factors are held constant.
- ***β_k(student and parent characteristics)$_{ijk}$*** is the estimated change in log-odds of not being fully ready for school for each independent variable comparing kindergartners with the selected variable to those without, holding all other characteristics constant.

Aim 3: *To examine whether Baltimore neighborhood characteristics modify the relation between LBW and PTB and school readiness, adjusting for maternal and child characteristics at birth and prior care characteristics at school entry.*

Results from **Aims 1 and 2** were used to construct regression models to estimate the impact of students' residence neighborhoods at birth on the relation between PTB and LBW and school readiness, adjusting for other relevant confounders. Specifically, student and parent characteristics included in model 5 above were used to examine whether neighborhood characteristics significantly confound the adjusted relation between PTB and LBW and school readiness. HLMs included random intercepts for student cohort years and neighborhoods to account for the clustering of students within cohort years and neighborhoods of residence at birth. Model 6 estimated the impact on PTB and LBW mean readiness scores after including all three levels (cohort year, neighborhood, and school) as random intercepts. Again, each models fit to the underlying data was evaluated using the AIC value. The following table shows the steps of the regression analysis for **Aim 3**.

Variable	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**
Main independent variables (PTB and LBW)	X	X	X	X	X	X
Other student variables (includes prior care settings)			X	X	X	X
Parent variables				X	X	X
Neighborhood variables		X			X	X
School intercept						X

Results from model 4 above will be used to evaluate **Aims 1 and 2**, and the full model notation is described in the following:

$$Y_{ijl} = \beta_{00} + \beta_{10}(cohort\ year\ spline)_{ijl} + \beta_{10}(LBW)_{ijl} + \beta_{20}(PTB)_{ijl} + \beta_{30}(prior\ care\ setting)_{ijl} +$$

$$\beta_{k0}(student\ and\ parent\ characteristics)_{ijl} + \beta_{0k}(neighborhood\ characteristics)_{l} + \varepsilon_{ijl}$$

Where,

- $\boldsymbol{Y_{ijl}}$ represents the mean readiness score for the i^{th} kindergartner of the j^{th} cohort year within the l^{th} neighborhood.
- $\boldsymbol{B_{00}}$ represents the mean school readiness score for a given kindergartner in an average neighborhood.
- ***β_{10}(Cohort year spline)$_{ijl}$*** is the estimated change in mean readiness score comparing students entering school in fall 2005 and earlier to students entering

school in fall 2006 and later for the i^{th} kindergartner of the j^{th} cohort year within the l^{th} neighborhood, adjusting for other model variables.

- $\boldsymbol{B_{20}(PTB)_{ijl}}$ is the estimated change in mean readiness score comparing kindergartners in PTB categories to full term kindergartners for the i^{th} kindergartner of the j^{th} cohort year within the l^{th} neighborhood, holding all other risk factors are constant.
- $\boldsymbol{B_{30}(LBW)_{ijl}}$ is the estimated change in mean readiness score comparing kindergartners in LBW categories to normal birth weight kindergartners for the i^{th} kindergartner of the j^{th} cohort year within the l^{th} neighborhood, adjusting for all other risk factors.
- $\boldsymbol{B_{40}(Prior\ Care)_{ijl}}$ is the estimated change in mean readiness score comparing kindergartners who did not enrolled in each non-district PK program to those that did enroll in a district PK program prior to kindergarten for the i^{th} kindergartner of the j^{th} cohort year within the l^{th} neighborhood, given all other risk factors are held constant.
- $\boldsymbol{\beta_{k0}(student\ and\ parent\ characteristics)_{ijl}}$ is the estimated change in mean readiness score for each one unit increase in the independent variable comparing kindergartners with the selected variable to those without, holding all other characteristics constant.
- $\boldsymbol{\beta_{0k}(neighborhood\ characteristics)_{l}}$ represents the random k^{th} effects of the l^{th} neighborhood on the mean change in school readiness score for the average kindergartner.
- $\varepsilon_{ijl} \sim N(0, \sigma^2)$

These methods were used to assess the main study aims. The main findings of the analyses are provided in the next chapter.

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CHAPTER FOUR

RESULTS

Overview

This chapter describes the findings for each study aim: 1) to determine whether LBW and PTB are related to school readiness among Baltimore City kindergarten students, adjusting for parent and child characteristics at birth; 2) to assess whether type of prior care moderates the relation between LBW and PTB and school readiness, after adjusting for other student and parent characteristics; and 3) to determine whether Baltimore neighborhood characteristics modify the relation between LBW and PTB and school readiness, adjusting for parent and child characteristics at birth and prior care characteristics at school entry.

The chapter begins with a description of the final study sample of Baltimore City born first time kindergarten students with a school readiness assessment completed between the fall of 2002 and 2012. The next section describes the dependent variables, composite and domain school readiness scores. The third section illustrates the relation between each independent variable and school readiness scores through bivariate analysis. The fourth section describes the main findings of multivariate regression models for aims 1 & 2. The findings for aim 3 are described in the fifth and final section of the chapter.

Study Sample

The characteristics of the kindergarten students in the final study sample are shown in **Table 3**. Noticeably, the percent of kindergartners born LBW (< 2500 grams) was 13.7%, slightly higher than the average LBW prevalence in Baltimore City from 2002 to 2012 (12.8%) (**Figure 1**). The prevalence of PTB (< 37 weeks) in the study sample was 14.6%, again slightly higher than the average PTB prevalence of 13.8% in

Baltimore City from 2002 to 2012 (MDHMH, 2012). Similar to the demographic characteristics of students enrolled in Baltimore City Public Schools (BCPS), more than 80% of the study sample were non-Hispanic (NH) Black (86.6%) or FARMS (83.4%) students; three-quarters of the sample consisted of NH Black students who were also FARMS (not shown in the table). Eight percent of the sample had some form of disability for which an individualized education program (IEP) was needed.

Half of students attended a district PK program in the 12 months prior to entering kindergarten, while nearly a quarter received informal home care. If students were not five at school entry, they tended to be younger than five rather than older; less than one percent was six or older. Similar to national reports of abnormal conditions and pregnancy complications on birth certificates (Martin, 2013), the frequency of these conditions was less than five percent in the study sample. The most frequently reported condition was fetal distress (3.7%) followed by breech/mal-presentation (2.5%). Ten percent of kindergarten students had low Apgar scores (less than 7) at one minute, but the prevalence was less than 2% for five minute scores.

Parent characteristics of the kindergarten students from the birth certificate are also presented in **Table 3**. The majority of mothers were NH Black (85%), but unexpectedly, given the student distributions of race/ethnicity, more than one-third of fathers were of Hispanic origin (**Table 4**). Further exploration revealed that the frequency of racial combinations of parents was NH Black mother and father (52.7%), NH Black mother and Hispanic father (31.0%), NH White mother and father (7.3%), Hispanic mother and father (2.5%), NH White mother and Hispanic father (2.2%), NH White mother and NH Black father (1.2%), followed by several other combinations of those with data reported about fathers (not shown in table). Only 18.1% of mother's were married at the time of the students' birth, approximately six percentage points lower than the 24.1% estimate of currently married individuals in Baltimore City based on 2010 US Census data. One-quarter of mothers were younger than 20 at the time of the child's birth, and about six percent were 35 years or older. On average, mothers had slightly less than 12 years of education (about a high school diploma). Thirteen percent of mothers reported some form of tobacco use during pregnancy. The mean number of maternal medical factors was lower than the mean number of labor complications; however both were very rare (<1 each), and the most frequently reported condition was maternal anemia (4%). Paternal information (education, age, and place of birth) was absent on 27.8% of birth certificates.

Table 3. Descriptive statistics of kindergartners in the final study sample of Baltimore City born kindergartners, 2002 to 2012

Category	Variable	N	M or %	SD
Main independent variables				
Birth weight	Mean birth weight	39,463	3,095.4	620.2
	NBW	34,067	86.3	
	LBW	5,396	13.7	
	MLBW	4,477	11.3	
	VLBW	551	1.4	
	ELBW	368	0.9	
Gestational Age	Mean gestational age	39,463	38.3	2.5
	Full-term	22,424	56.8	
	Post-term	333	0.8	
	Early-term	10,964	27.8	
	PTB	5,742	14.6	
	MPTB	3,908	9.9	
	VPTB	1,474	3.7	
	EPTB	360	0.9	
Prior Care Setting	District PK	19,693	49.9	
	Informal home care	8,973	22.7	
	Head Start	4,839	12.3	
	Child care center	1,810	4.6	
	Family child care	1,082	2.7	
	Private nursery PK	983	2.5	
	Other PK	2,083	5.3	
Student characteristics at school entry				
Gender	Male	19,934	50.5	
	Female	19,529	49.5	
ELL status	Non-ELL	38,419	97.4	
	ELL	1,044	2.7	
FARMS status	Non-FARMS	6,536	16.6	
	FARMS	32,927	83.4	
Disability status	Disabled	3,063	7.8	
	General education	35,116	89.0	
	Missing	1,284	3.3	
Age at school entry	Mean age (months)	39,463	64.5	3.8
	Five	36,270	91.9	
	Under 5	2,854	7.2	
	6 and older	339	0.9	
Race/Ethnicity	NH Black	34,179	86.6	
	NH White	3,703	9.4	
	Hispanic	1,295	3.3	
	NH Asian	155	0.4	
	NH Other	131	0.3	
K Cohort	2005 and earlier	10,924	27.7	
	2006 and later	28,539	72.3	
Student characteristics at birth				
Number of siblings	Mean siblings	39,328	1.2	1.4
	None	15,225	38.6	
	One	11,460	29.0	
	Two or more	12,643	32.0	

	Missing	135	0.3	
Plurality	Singleton birth	38,106	96.6	
	Multiple birth	1,357	3.4	
Abnormal conditions of the newborn	# Conditions	39,463	0.0	0.2
	Assisted Ventilation	383	1.0	
	Anemia	39	0.1	
Complications of labor and/or delivery	# Complications	39,463	0.4	0.6
	Fetal distress	1,472	3.7	
	Placenta previa	84	0.2	
	Breech/malpresentation	991	2.5	
One-minute Apgar scores	High score	35,361	89.6	
	Low score	3,961	10.0	
	Missing	141	0.4	
Five-minute Apgar scores	High score	38,751	98.2	
	Low score	579	1.5	
	Missing	133	0.3	
<u>Parent characteristics at birth</u>				
Maternal race/ethnicity	NH Black	33,636	85.2	
	NH White	4,368	11.1	
	Hispanic	1,092	2.8	
	NH Asian	29	0.1	
	NH Other	320	0.8	
	Missing	18	0.1	
Paternal race/ethnicity	NH Black	21,408	54.3	
	NH White	3,102	7.9	
	Hispanic	14,143	35.8	
	NH Asian	20	0.1	
	NH Other	289	0.7	
	Missing	501	1.3	
Maternal birth place	US born	37,113	94.0	
	Foreign born	2,074	5.3	
	Missing	276	0.7	
Maternal age	Mean age	39,448	24.3	6.2
	20 to 35	26,856	68.1	
	< 20	10,098	25.6	
	36+	2,494	6.3	
	Missing	15	0.0	
Maternal years of education	Mean years	38,788	11.8	2.2
	13+ years	8,085	20.5	
	Less than 12 years	16,343	41.4	
	12 years	14,360	36.4	
	Missing	675	1.7	
Marital status	Not married	32,304	81.9	
	Married	7,159	18.1	
Maternal tobacco use	No	34,039	86.3	
	Yes	5,317	13.5	
	Missing	107	0.3	
Pregnancy related medical factors	# Medical factors	39,463	0.4	0.6
	Anemia	1,557	4.0	
	Gestational diabetes	1,026	2.6	
	Eclampsia	167	0.4	
	Previous PTB	547	1.4	

Paternal data on birth certificate[§]	Present	28,495	72.2
	Absent	10,968	27.8

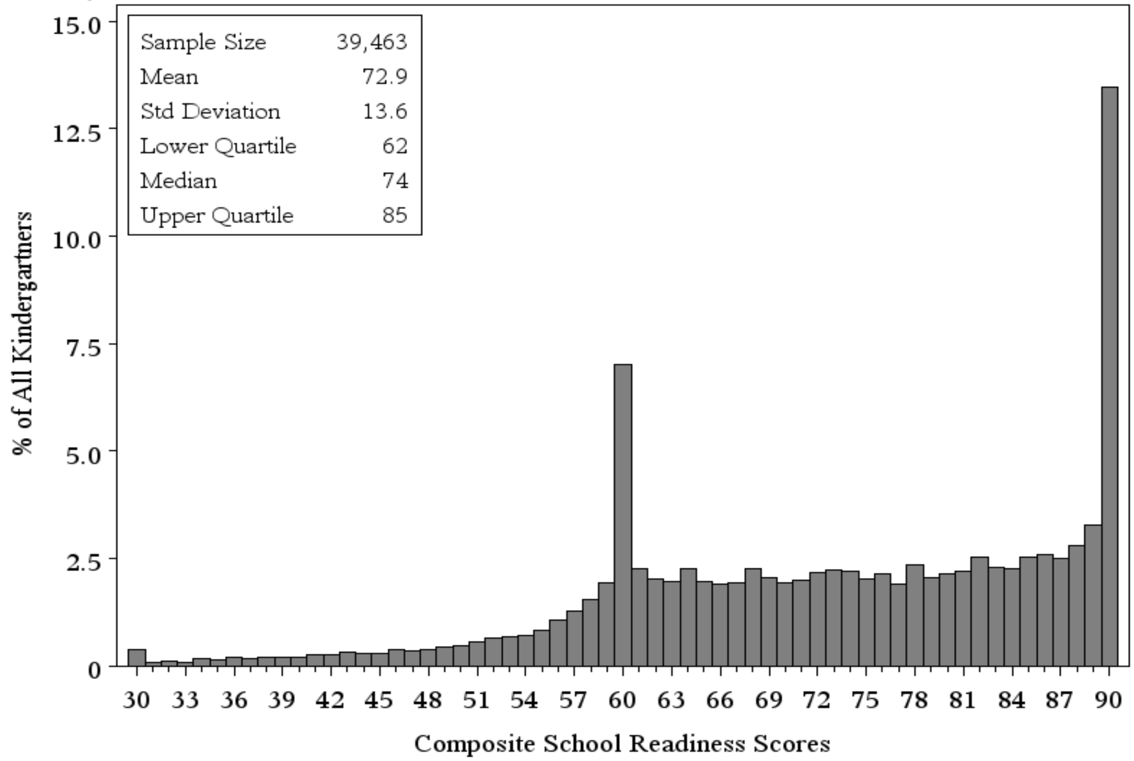
NH: non-Hispanic † includes American Indian/Alaskan Native, Native Hawaiian/Other Pacific Islander, and Multiple Race
[§]Missing paternal indicators of educational attainment, age, and birth place

Dependent Variable

Composite and Domain Specific School Readiness Scores

The percentage of kindergarten students rated 'approaching' or 'fully ready' for school in kindergarten increased in Baltimore City each year since 2002 (BCPS, 2013). Likewise, the percentage of 'developing' and 'approaching' students fell each year from 6.8% and 60.2% in 2002, respectively, to 2.8% and 19.0% in 2012 in the study sample. The distribution of composite school readiness scores in the final study sample reflects this trend (**Figure 6**). On average, Baltimore City kindergarten students scored 72.9 (standard deviation = 13.6), nearly three points higher than the 'fully ready' cut-off of 70. Overall, 4.9% had readiness scores below 50 and were considered still developing school readiness. Fifteen percent had composite readiness scores less than 60, the cut-off used in the analysis of students with low scores. The median score was 74, but 12.5% of students scored a perfect 90 on the assessment. Fifty percent of scores ranged from 62 to 85.

Figure 6. Distribution of composite school readiness scores of Baltimore City born kindergarten students, 2002 to 2012



Domain readiness scores were standardized by cohort year to account for the greater range of possible scores in the language & literacy domain with scores from 6 to 18; other domain scores ranged from 4 to 12. Student scores for each domain were standardized so that each score represented the deviation from the cohort year mean score as a proportion of the observed standard deviation. A description of the raw domain readiness scores mean and variance overall weighted mean scores and standard deviations for all 39,463 students is provided in **Table 4.1**.

Table 4.1 Weighted mean raw domain readiness scores and standard deviations, 2002 to 2012

Domain	Range	Mean	SD
Language & Literacy	6 to 18	14.3	3.29
Mathematical Thinking	4 to 12	9.5	2.20
Scientific Thinking	4 to 12	9.1	2.14
Social Studies	4 to 12	9.3	2.07
Social & Personal Development	4 to 12	9.9	2.15
The Arts	4 to 12	10.3	1.99
Physical Development & Health	4 to 12	10.6	1.84

SD: standard deviation

The median standardized domain readiness scores for the language and literacy and mathematical thinking domains were nearly one-tenth of a standard deviation (SD) above the cohort year mean (average); suggesting that most students scored above average in these domains (**Table 4.2**). Scientific thinking and reports of social studies of readiness scores tend to be lower, as half of students scored nearly one-tenth of a SD below the study sample average in these domains. The highest mean domain readiness scores were in the social and personal development, the arts, and the physical development and health domains where half of the study sample had scores at least one-third of a SD above the average.

Table 4.2 Mean standardized* domain school readiness scores

Domain	Minimum	Q1	Median	Q3	Maximum
Language & Literacy	-3.10	-0.70	0.08	0.83	1.92
Mathematical Thinking	-3.01	-0.70	0.07	0.87	2.11
Scientific Thinking	-2.89	-0.60	-0.08	0.86	2.42
Social Studies	-3.17	-0.69	-0.07	0.80	2.48
Social & Personal Development	-3.53	-0.58	0.28	0.85	1.49
The Arts	-4.28	-0.70	0.57	0.74	1.53
Physical Development & Health	-5.27	-0.75	0.47	0.65	1.34

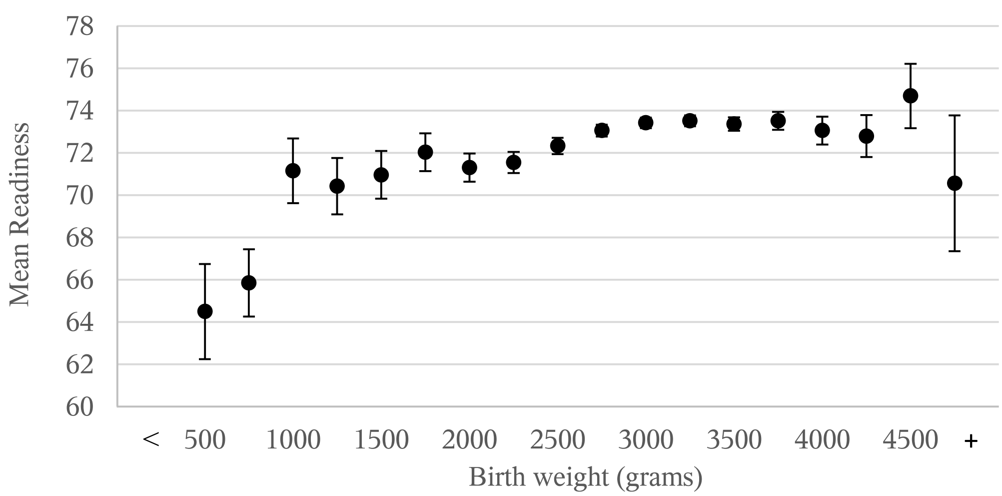
Q1: lower quartile Q3: upper quartile
*Domain scores were standardized for each kindergarten cohort year to a mean of 0 and standard deviation of 1

Bivariate Analysis

Birth weight

The relation between birth weight (BW) and readiness scores, was examined using both continuous and categorical variables in this bivariate analysis. A small but statistically significant linear correlation was observed between birth weight ($r=0.06$; $p<0.0001$) and school readiness in the final study sample. Mean composite readiness scores with 95% confidence intervals (CI) by 250 gram birth weight intervals are presented in **Figure 7.1**. Readiness scores of students who weighed more than 1000 grams (2.2 pounds) at birth were higher and within range of each other, but readiness scores of students who weighed less than 1000 grams at birth were significantly lower. Readiness scores appeared to be highest for students with a birth weight of 4500 grams, but lower readiness scores were observed for students who were heavier than that at birth.

Figure 7.1 Mean composite school readiness scores with 95% confidence intervals, 2002 to 2012, by birth weight



A comparison of unadjusted mean readiness scores by LBW categories showed that composite (F-stat=65.9, $p<0.0001$) and domain readiness scores varied significantly by LBW type. Students born of normal birth weight (NBW, ≥2500 grams) had the highest readiness scores and extremely LBW (ELBW, <1000 grams) students, the lowest scores for the composite and each domain (**Table 5.1**). The gap in school readiness scores between NBW and LBW students was more than two points, but an eight point readiness gap was observed between NBW and ELBW students (p<0.01). NBW students scored slightly higher than average across readiness domains while ELBW students scored more than half a SD lower than the average in most domains. Very LBW (VLBW, 1000 – 1499 grams) students had mean readiness scores that were slightly lower than moderately LBW (MLBW, 1500 – 2499 grams) students for the composite and in each domain.

Table 5.1 Mean composite and standardized domain school readiness scores of Baltimore City born kindergartners, 2002 to 2012, by birth weight categories

	Composite	Language & Literacy	Math Thinking	Social & Personal
NBW (ref)	73.2 (13.4)	0.02 (0.99)	0.02 (0.99)	0.01 (0.99)
LBW	71.0 (14.3)**	-0.15 (1.06)**	-0.15 (1.06)**	-0.09 (1.05)**
MLBW	71.5 (14.1)**	-0.12 (1.05)**	-0.12 (1.05)**	-0.06 (1.04)**
VLBW	70.7 (14.3)**	-0.20 (1.07)**	-0.18 (1.04)**	-0.12 (1.07)**
ELBW	65.3 (15.1)**	-0.56 (1.14)**	-0.55 (1.18)**	-0.38 (1.05)**

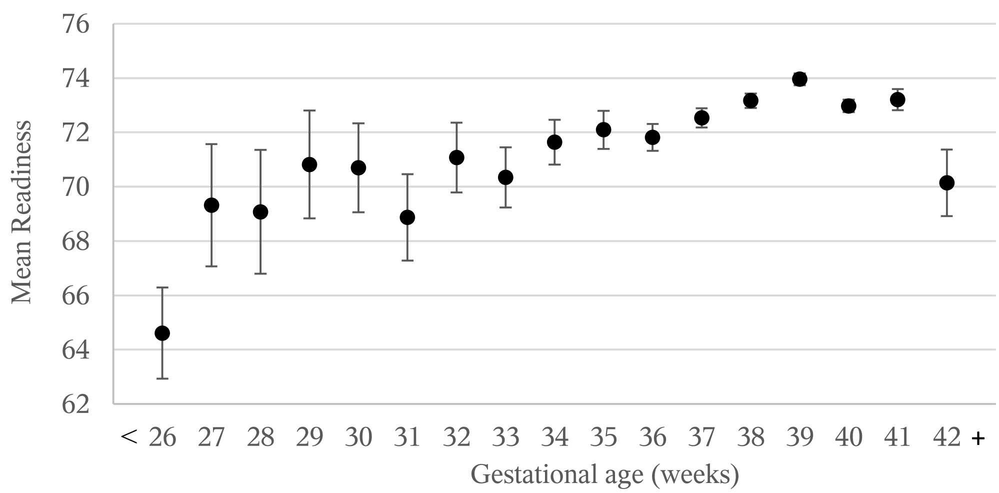
	Scientific Thinking	Social Studies	The Arts	Physical Development & Health
NBW (ref)	0.02 (0.99)	0.02 (0.99)	0.01 (0.99)	0.02 (0.98)
LBW	-0.13 (1.05)**	-0.12 (1.06)**	-0.07 (1.04)**	-0.10 (1.09)**
MLBW	-0.10 (1.03)**	-0.09 (1.04)**	-0.05 (1.04)**	-0.07 (1.07)**
VLBW	-0.16 (1.04)**	-0.12 (1.08)**	-0.09 (1.04)*	-0.13 (1.07)**
ELBW	-0.49 (1.17)**	-0.46 (1.15)**	-0.35 (1.09)**	-0.54 (1.24)**

ref: reference category standard deviations provided in parentheses NBW: normal birth weight (≥ 2500 grams) LBW: low birth weight (<2500 grams) MLBW: moderately LBW (1500 - 2499 grams) VLBW: very LBW (1000 - 1499 grams) ELBW: extremely LBW (<1000 grams)
** p < 0.01 * p < 0.05

Gestational Age

Similar to trends in increasing birth weight, students born at later gestational ages (GA) tended to have higher composite school readiness scores (**Figure 7.2**). A small but statistically significant linear correlation between gestational age in weeks (r=0.06; p<0.0001) and school readiness was observed. A noticeable drop in scores was observed after 41 completed weeks of gestation. Students born at 39 weeks gestation had the highest composite readiness scores while those born prior to 26 completed weeks gestation had the lowest scores, on average.

Figure 7.2 Mean composite school readiness scores with 95% confidence intervals, 2002 to 2012, by gestational age



Significant differences in mean readiness scores between GA categories were observed for the composite (F-stat=43.6, p<0.0001) and each domain of readiness (**Table 5.2**). Full-term students had mean composite readiness scores that were more than seven points higher than extremely PTB (EPTB) students (p<0.01). Students born post-term had mean composite readiness scores similar to students born very PTB (VPTB) and standardized domain readiness scores that were generally higher than VPTB students, but lower than students born moderately PTB (MPTB, 34-36 weeks). The lowest composite and standardized domain readiness scores were observed among students born EPTB.

Table 5.2 Mean composite and standardized domain school readiness scores of Baltimore City born kindergartners, 2002 to 2012, by gestational age categories

	Composite	Language & Literacy	Math Thinking	Social & Personal
Full-term (ref)	73.4 (13.4)	0.04 (0.99)	0.04 (0.98)	0.03 (0.99)
Post-term	70.2 (13.6)**	-0.13 (1.02)**	-0.08 (1.02)*	-0.10 (1.03)*
Early-term	72.9 (13.5)**	-0.01 (0.99)**	-0.02 (1.00)**	-0.01 (1.00)**
PTB	71.1 (14.1)**	-0.14 (1.05)**	-0.14 (1.05)**	-0.09 (1.03)**
MPTB	71.9 (13.8)**	-0.08 (1.02)**	-0.08 (1.03)**	-0.04 (1.02)**
VPTB	70.3 (14.3)**	-0.23 (1.06)**	-0.20 (1.06)**	-0.16 (1.06)**
EPTB	66.1 (15.6)**	-0.50 (1.15)**	-0.49 (1.18)**	-0.34 (1.07)**

	Scientific Thinking	Social Studies	The Arts	Physical Development & Health
Full-term (ref)	0.04 (0.99)	0.03 (0.99)	0.02 (0.99)	0.03 (0.98)
Post-term	-0.07 (1.02)*	-0.08 (1.00)*	-0.12 (1.02)**	-0.14 (1.00)**
Early-term	-0.01 (1.00)**	-0.01 (1.00)**	-0.01 (1.00)**	0.00 (0.99)*
PTB	-0.11 (1.03)**	-0.10 (1.03)**	-0.07 (1.03)**	-0.10 (1.07)**
MPTB	-0.06 (1.01)**	-0.05 (1.01)**	-0.03 (1.01)**	-0.03 (1.03)**
VPTB	-0.16 (1.03)**	-0.16 (1.05)**	-0.13 (1.06)**	-0.18 (1.09)**
EPTB	-0.41 (1.17)**	-0.41 (1.17)**	-0.33 (1.10)**	-0.52 (1.26)**

ref: reference category   standard deviations provided in parentheses
Full-term: 39 - 41 weeks Post-term: 42+ weeks   Early-term: 37-38 weeks
PTB: preterm birth, 37 weeks MPTB: moderately PTB, 34 - 36 weeks
VPTB: very PTB, 28-33 weeks EPTB: extremely PTB, <28 weeks
** $p < 0.01$ * $p < 0.05$

Prior Care Settings

Considerable variation in composite and domain readiness scores was observed among the different types of prior care settings. Mean composite school readiness scores were highest among students who entered kindergarten after attending a prekindergarten (PK) program in the twelve months prior to school entry (**Table 5.3**). Private nursery PK program students had the highest readiness scores that were statistically significantly different from district PK students in all domains except for the composite, the arts, and physical development & health. The lowest readiness scores were observed among students who entered kindergarten from an informal home care setting. The mean composite readiness score for informal home care students was nearly nine points lower than for district PK students; the next lowest mean scores were among family child care students (seven points lower). Informal home care students also had domain readiness scores at least two-tenths of a SD below average. Kindergarten students who attended a Head Start program prior to entering school had slightly higher mean composite readiness scores than students who attended a child care center and standardized domain readiness scores that were slightly lower than the cohort year mean.

Table 5.3 Mean composite and standardized domain school readiness scores of Baltimore City born kindergartners, 2002 to 2012, by prior care setting

	Composite	Language & Literacy	Math Thinking	Social & Personal
District PK (ref)	75.9 (12.8)	0.18 (0.92)	0.18 (0.92)	0.10 (0.96)
Private nursery PK	76.3 (12.2)	0.32 (0.86)**	0.33 (0.86)**	0.20 (0.91)**
Other PK	73.0 (13.6)**	0.02 (1.02)**	0.02 (1.01)**	0.04 (0.99)**
Head Start	72.3 (12.9)**	-0.07 (0.97)**	-0.08 (0.96)**	-0.05 (1.00)**
Child care center	71.9 (13.0)**	-0.05 (0.96)**	-0.04 (0.97)**	-0.10 (1.01)**
Family child care	69.4 (13.8)**	-0.35 (1.05)**	-0.36 (1.06)**	-0.20 (1.08)**
Informal home care	67.1 (13.7)**	-0.35 (1.08)**	-0.35 (1.09)**	-0.18 (1.05)**

	Scientific Thinking	Social Studies	The Arts	Physical Development & Health
District PK (ref)	0.12 (0.96)	0.12 (0.96)	0.09 (0.95)	0.11 (0.93)
Private nursery PK	0.33 (0.89)**	0.28 (0.91)**	0.07 (0.90)	0.08 (0.88)
Other PK	0.02 (1.05)**	0.05 (1.04)**	0.02 (1.03)**	0.01 (1.01)**
Head Start	-0.05 (0.95)**	-0.05 (0.94)**	-0.02 (0.98)**	-0.02 (0.97)**
Child care center	0.00 (0.94)**	-0.01 (0.96)**	-0.02 (0.98)**	-0.06 (0.99)**
Family child care	-0.24 (1.02)**	-0.24 (1.01)**	-0.12 (1.07)**	-0.15 (1.09)**
Informal home care	-0.25 (1.05)**	-0.25 (1.07)**	-0.19 (1.09)**	-0.20 (1.12)**

ref: reference category   standard deviations provided in parentheses   PK: prekindergarten
** $p < 0.01$ * $p < 0.05$

Other Independent Variables

Several student factors were associated with school readiness in the final study sample. Female students had mean composite readiness scores that were more than three points higher than males ($p<0.01$) and standardized domain readiness scores that ranged from 0.07 SDs above the study sample average in the scientific thinking domain to 0.19 SDs above average for the social and personal domain. Male domain readiness scores ranged from 0.18 SDs below average in the social and personal domain to 0.06 SDs below average in the scientific thinking domain.

Few statistically significant differences in mean readiness scores were observed between race and ethnicity categories. The only significant difference in mean composite readiness scores was for Hispanic students whose mean readiness scores were 1.5 points higher than NH Black students ($p<0.01$). In general, NH Black students had domain specific mean readiness scores that were equal to the cohort year mean, which was expected given that NH Black students made up 87% of the study sample. No apparent Black-White readiness gap was observed in the unadjusted bivariate analysis, although NH White students had language and literacy and mathematical thinking domain readiness scores that were nearly one-tenth a SD above average and significantly higher than NH Black students ($p<0.01$). Hispanic students had language and literacy and mathematical thinking domain scores that were below average, but social and personal readiness scores 0.06 SDs above average. NH Asian students had readiness scores that were 0.16 SDs above average in the social and personal domain, significantly higher than scores for NH Black students.

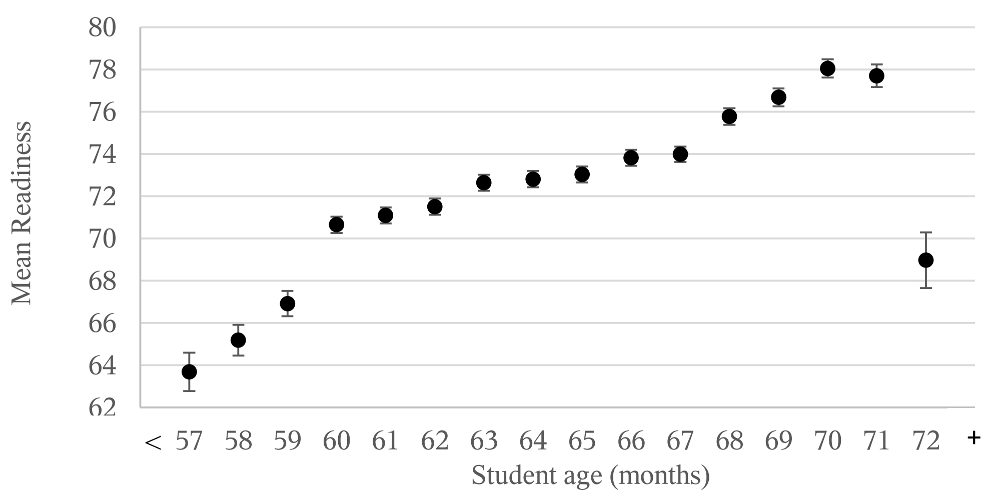
The higher unadjusted mean composite readiness scores of Hispanic students compared to NH Black students is largely a factor of increased enrollment of Hispanic students after the 2006 school year when readiness scores increased substantially. Domain readiness scores were standardized by cohort year, explaining why Hispanic student's domain readiness scores were lower than average, while their unadjusted composite readiness scores were above average.

FARMS status served as a proxy for the students' family income at the time of school entry for the current study. The majority of BCPS students are FARMS students. A comparison of mean composite readiness scores revealed that non-FARMS students had scores that were more than one point higher than FARMS students' readiness scores ($p<0.01$). Domain specific readiness scores were above average for non-FARMS students, but there was little variation in scores across domains. Non-FARMS scores ranged from 0.05 SDs in the physical development and health domain to 0.17 SDs in the mathematical thinking domain. FARMS students' domain readiness scores were all below average, but no discernable difference was observed across domains.

Students with a disability (SWD) had statistically significant lower composite mean readiness scores than non-SWD or general education students in the final sample. Mean composite readiness scores for SWD's were more than eight points lower than the scores for general education kindergartners ($p<0.01$). Kindergarten SWD's had mean readiness scores that were about half a SD below average across domains while general education kindergartners scored above average in each domain. SWD domain readiness scores ranged from -0.65 in the language and literacy domain to -0.43 SDs in the arts domain, while general education students' domain readiness scores ranged from 0.04 to 0.06 SDs above average.

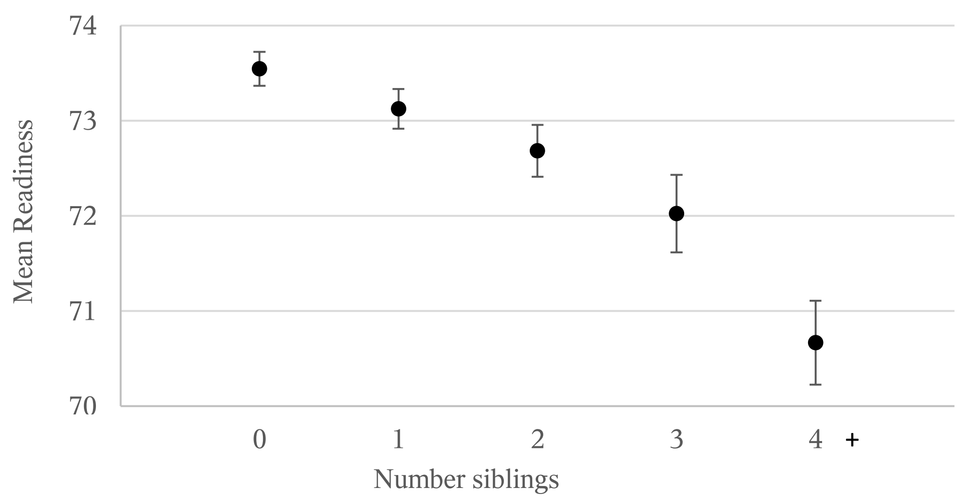
The relation between increasing student age at school entry and composite school readiness scores resembled an inverted U-shaped curve, such that younger and much older students had lower mean readiness scores compared to five year old students. Mean composite readiness scores were highest for students who were older than five (60 months) and less than six years old (72 months) on September 1st at school entry (**Figure 7.3**). Mean scores were actually highest for older five year olds as compared to younger five year olds, but mean scores dropped substantially for kindergarten students who are six or older. Kindergarten students who entered school younger than five years old had mean composite readiness scores that were lower than students six and older as well. Both younger and older students had significantly lower domain readiness scores than students who were five at school entry ($p<0.01$), but mean scores for older students were substantially lower than mean scores of younger students.

Figure 7.3 Mean composite school readiness scores with 95% confidence intervals, 2002 to 2012, by student age at school entry



An inverse relation was observed between the number of siblings and mean composite school readiness (**Figure 7.4**). First born kindergarten students had the highest mean composite school readiness scores while those with one or more siblings had significantly lower scores. No significant difference in domain readiness scores was observed between first born students and those with only one other sibling. Students with two or more siblings had significantly lower domain readiness scores that ranged from -0.09 SDs in the language and literacy and mathematical thinking domains to -0.03 SDs in the physical development and health domain. No significant difference in mean composite readiness scores were observed for multiple births as compared to singleton births. Multiple birth students, however, had mean standardized language and literacy, mathematical thinking, and scientific thinking domain readiness scores that were significantly lower than singleton births.

Figure 7.4 Mean composite school readiness scores with 95% confidence intervals, 2002 to 2012, by number of siblings at birth



Perinatal and neonatal characteristics were also significantly associated with school readiness. Thirty-two percent of students in the final study sample had at least one labor and/or delivery complication reported on the birth certificate. A small negative correlation between number of complications and mean composite readiness scores was observed (r = -0.01; p=0.0005). The four percent of students who experienced fetal distress during labor had a mean composite readiness score that was 1.2 points lower than students born without fetal distress (p<0.01); only four percent of students (n=1,711) had an abnormal newborn condition reported on the birth certificate. The number of abnormal conditions reported was weakly associated with lower composite school readiness scores (r = -0.01; p=0.0073), but students born anemic (0.1%) and those needing neonatal assisted ventilation (1%) had respective unadjusted mean composite readiness scores that were 5.6 (p<0.05) and 3.2 (p<0.01) points lower than students born without each condition.

Students who received neonatal assisted ventilation had lower language and literacy, mathematical thinking, social and personal, and scientific thinking mean domain readiness scores as well. Students born anemic also had mean mathematical thinking domain readiness scores that were -0.35 SDs below average. Kindergarten students with low one or five minute Apgar scores had mean composite readiness scores 1.6 points lower than students with high Apgar scores at both one and five minutes post-birth (p<0.01). Low Apgar score students had significantly lower mean domain readiness scores as well.

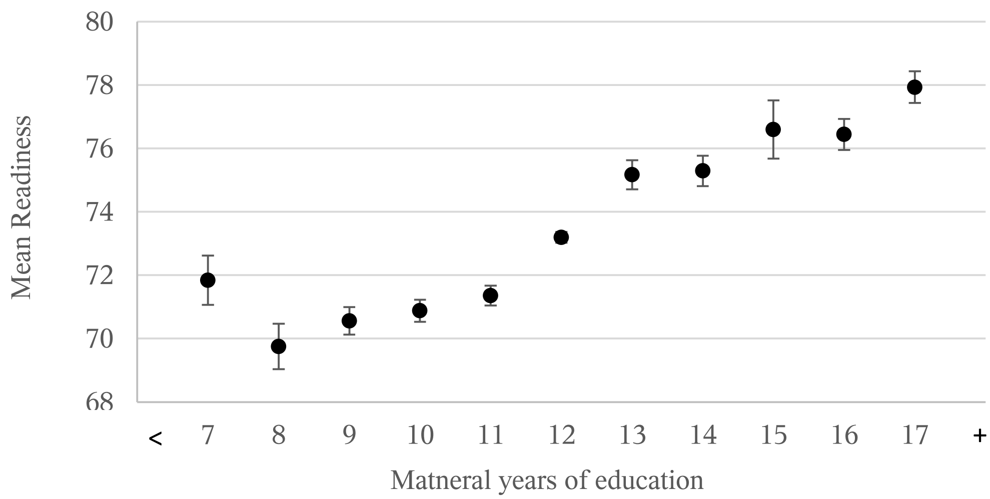
Parent variables associated with kindergarten school readiness scores included maternal and paternal race, maternal age and years of education, maternal nativity, marital status, maternal tobacco use, maternal report of a prior PTB, and missing paternal information on the birth certificate. Similar to differences in school readiness by student race, only students of Hispanic and NH Asian parents had significantly higher mean composite readiness scores than students of NH Black parents. No significant difference in mean composite school readiness scores was observed between students of NH Black and NH White parents, but students of NH White parents had significantly higher language and literacy and mathematical thinking mean domain readiness scores ($p<0.01$); the differences by paternal race was greater than differences by maternal race.

The majority of students in the study sample (82%) were born to unmarried parents. Bivariate analysis revealed that students of married parents had significantly higher mean composite readiness scores by about two points as compared to students born to unmarried parents ($p<0.01$). Kindergarten students of married parents also had language and literacy and math thinking domain readiness scores more than one-tenth of a SD above average, while kindergarten students born to unmarried parents had domain readiness scores that were below average.

Students with missing paternal information on their birth certificate had significantly higher unadjusted mean composite readiness scores than students whose paternal information was reported on the birth certificate, but significantly lower than average domain readiness scores. More than 90% of students with absent paternal information had Hispanic fathers reported on their birth certificate, which may explain the difference in composite and domain readiness scores of these students.

The relation between maternal years of education and mean composite readiness scores resembled a U-shaped curve (**Figure 7.5**). Students of mothers with the least years of education had slightly higher mean composite readiness scores than those with eight to ten years of education. The readiness scores among this group of students was likely due to no difference in readiness scores for children of NH Black and Hispanic mothers while children of NH White mothers had the lowest scores; scores were highest for students of mothers with other race classifications. Kindergarten students of mothers with at least thirteen years of education had mean composite school readiness scores that were three and five points higher than students of mothers with twelve and less than twelve years of education, respectively (p<0.01). Students of mothers with twelve or more years of education had mean domain readiness scores that were well above average, while students of mothers with less than twelve years of education had mean domain readiness scores at least one-tenth of a SD below average.

Figure 7.5 Mean composite school readiness scores with 95% confidence intervals, 2002 to 2012, by maternal years of education



Kindergarten students born to older mothers had higher mean composite readiness scores than those born to younger mothers. Students of teenage mothers had mean composite readiness scores that were 1.1 points lower than scores of students born to mothers aged 20 to 35 years old (p<0.01). Mean domain readiness scores were also lower for students of teenage mothers. No significant difference in mean composite or domain readiness scores was observed between students born to mothers 36 and older and mothers between 20 and 35 at the time of birth.

Kindergarten students of foreign born mothers had mean composite readiness scores 1.7 points higher than students of US born mothers ($p<0.01$). They also had significantly higher mean mathematical thinking, social and personal, and physical development and health domain readiness scores. Interestingly, students of foreign born mothers had mean standardized social and personal domain readiness scores that were one-tenth of a SD above average, while students of US born mothers had mean social and personal domain scores slightly below average.

Tobacco use during pregnancy had a significant negative effect on school readiness in the final study sample. Kindergarten students of mothers who reported using tobacco at some time during pregnancy had mean composite readiness scores that were about three points lower than students of mothers who did not use during pregnancy ($p<0.01$). Students of mothers who used tobacco also had domain readiness scores at least one-tenth of a SD below average, while students of mothers who did not use tobacco had mean domain readiness scores above average.

Maternal medical risk factors were present for about 30% of the final study sample. The only individual risk factor showing a significant difference in mean readiness scores was for the 1.4% (n=547) of students born to mothers who reported a previous PTB. These students had mean composite readiness scores 2.3 points lower than those of students whose mother did not report a previous PTB ($p<0.0001$).

Based on the initial bivariate analysis, the following variables were considered for further multivariable analysis of the relation between PTB and LBW and school readiness: type of prior care, student race, student age, SWD status, FARMS status, number of siblings, multiple birth, low Apgar scores, fetal distress, neonatal anemia, assisted ventilation, maternal and paternal race/ethnicity, marital status, missing paternal information, and maternal age, education, nativity, and tobacco use.

Confounder analysis

To confirm whether the aforementioned significant independent variables should be included in multivariate analyses with PTB and LBW as confounders, the association of each variable with the main independent variable was examined. Significant confounders were those associated with both school readiness and at least one of the main independent variables: PTB, LBW, or prior care setting.

A strong positive correlation was observed between gestational age (GA) and birth weight (BW) in the final study sample ($r=0.71$; $p<0.0001$). Mean BW (F-stat=20.1; $p<0.0001$) and GA (F-stat=11.4; $p<0.0001$) varied significantly by prior care setting. Students attending a district PK program had a mean BW of 3101 grams, significantly lower than the mean BW of those attending a child care center (3143 grams) or private nursery PK program (3261 grams). Students receiving informal home care had the lowest mean BW (3063 grams). More than half (50.2%) of students born NBW attended a district PK program while only 43.2% of students born ELBW did so. Students born LBW were less likely to attend a PK or other center based childcare program and had a 20% greater odds of receiving informal home care than NBW students (crude OR= 1.18; 95% CI: 1.11-1.26). Mean GA ranged from 38.2 weeks for informal home care students to 38.7 for students who attended a private nursery PK program. Students born PTB also had a 20% greater odds of receiving informal home care prior to entering kindergarten than students born at term (OR: 1.18; 95% CI: 1.11-1.27).

Mean BW varied significantly by student race and ethnicity (F-stat= 131.9; $p<0.0001$). NH Black students had the lowest mean BW (3068 grams), but only Hispanic (3294 grams) and NH Whites (3278 grams) had mean BW significantly higher than NH Black students. Similarly, mean gestational age (GA) varied by student race (F-stat=46.7; $p<0.0001$). Again, NH Black students had the shortest mean GA (38.2 weeks), and only Hispanic (38.8 weeks) and NH White (38.7 weeks) students had significantly longer pregnancies.

Type of prior care received varied significantly by race as well ($\chi^2 = 2362.2$; $p<0.0001$). More than fifty percent of NH Black and Hispanic students attended a district PK program in the twelve months before entering kindergarten while only forty percent of NH White students did so. Informal home care was highest among NH White students (25.2%) followed by NH Black (22.6%) and Hispanic (20.7%) students. Seventeen percent of NH Black students attended Head Start (13%) or another type of child care center (4.6%), compared to 14.2% of Hispanics and 10.6% of NH White students. Thirteen percent of NH White students attended a private nursery PK program, but only one percent of NH Black and Hispanic students attended a private nursery PK program.

The mean BW and GA of FARMS students was 84 grams lower and 0.2 weeks shorter than for non-FARMS students, respectively ($p<0.0001$). FARMS students were more likely to attend a district PK, Head Start or receive informal home care than non-FARMS students. Non-FARMS students had greater than ten times the odds of attending a private nursery PK program than FARMS students (odds ratio (OR)= 12.3; 95% CI: 10.7-14.1).

Students with disabilities (SWD) had mean BW's 104 grams lower ($p<0.0001$) and mean GA's 0.7 weeks shorter ($p<0.0001$) than general education students. Students born LBW (OR = 1.58; 95% CI: 1.43-1.73) or PTB (OR = 1.51; 95% CI: 1.37-1.65) had a greater than fifty percent odds of having a disability at school entry. Students born ELBW and EPTB had nearly five times the odds of having a disability at school entry compared to students not born ELBW or EPTB. SWDs were more likely to attend a district PK or Head Start program prior to entering kindergarten. They were less likely to receive informal home care than general education students.

The number of siblings at birth was negatively correlated with GA ($r=-0.10$; $p<0.0001$) and BW ($r=-0.03$; $p<0.0001$). On average, students receiving informal home care (mean=1.37; SD=1.6) or family child care (mean=1.25; SD=1.4) had the highest number of siblings, and those attending a private nursery PK program had the fewest number of siblings (mean=0.77; SD=1.0).

Perinatal and neonatal characteristics were associated with BW and GA. Students with low Apgar scores had mean BW's and GA's 300 grams lower and 1.5 weeks shorter than students born with high Apgar scores ($p<0.0001$). Prior care attendance did not vary significantly by Apgar score status ($\chi^2 = 11.9$; $p<0.0649$). Students who received neonatal assisted ventilation had mean BW's and GA's that were 933 grams lower and 5.0 weeks shorter than those of students who did not receive assisted ventilation ($p<0.0001$). Students with assisted ventilation had a 27% lower odds of attending a district PK program (OR=0.73; 95% CI: 0.59-0.89) and a 36% greater odds of receiving informal home care (OR=1.36; 95% CI: 1.08-1.70) prior to school entry. Students who experienced fetal distress during delivery were significantly lighter at birth by 108 grams

($p<0.0001$), but no significant difference in GA was observed. Overall, no statistically significant variation in the type of prior care received was observed by fetal distress status ($\chi^2 = 12.5$; $p=0.0517$).

The relation between parent characteristics and the main independent variables was also examined. Students born to married parents had respective mean BW's and GA's that were 128 grams heavier ($p<0.0001$) and 0.1 weeks longer ($p=0.0004$) than students born to un-married parents. The type of prior care also varied significantly by parent's marital status ($\chi^2 = 1470.1$; $p<0.0001$). Kindergarten students of married parents were more likely to attend a child care center, private nursery PK, or some other PK program.

Although no significant linear correlation was observed between maternal age and student BW ($r=-0.00$; $p=0.9031$), a small but significant negative correlation was observed for GA ($r=-0.07$; $p<0.0001$). The relation between maternal age and mean BW resembled an inverted U-shaped curve where younger and older mothers had lower mean BW's compared to mothers in the 20 to 34 year old age range. Mean maternal age varied by the type of prior care (F-stat=151.4; <0.0001). The mean maternal age of students attending a district PK program (mean=24.1; SD=6.0) was significantly younger than for students who attended a private nursery PK program (mean=29.9; SD=6.8), child care center (mean=25.2; SD=6.6) or other PK program (mean=24.7; SD=6.5).

Maternal years of education was positively correlated with BW ($r=0.05$; $p<0.0001$), but not with GA ($r=0.01$; $p=0.3642$). Type of prior care varied significantly by maternal education (F-stat= 394.8; $p<0.0001$). Students who attended a district PK program had a mean years of maternal education of 11.7 years (SD = 2.1). Mothers of students who received informal home care had the lowest mean years of education (mean=11.3 years; SD=2.1) while mothers who sent their students to a private nursery PK program had the highest mean years of education (mean=14.6 years; SD=2.5).

Students with missing paternal information on their birth certificate had mean BW's 59 grams lower than those whose paternal information was reported on the birth certificate ($p<0.0001$). No significant difference in mean GA's was observed ($p=0.1497$). The majority of students with missing paternal information attended a district PK program (52.6%), followed by informal home care (23.0%) and Head Start (12.2%) prior to school entry. Ninety percent of students with missing paternal information (education, age and birth place) on the birth certificate had mothers with twelve or fewer years of education (87.7%) or were born to Hispanic fathers (90.9%).

Students born to foreign-born mothers were significantly heavier (mean diff=182.5 grams; $p<0.0001$), had longer GA's (mean diff=0.5 weeks; $p<0.0001$), and had a greater odds of having attended a private nursery PK program, other PK program, or received informal home care than students of US born mothers. Maternal tobacco use was associated with significantly lighter BW's (mean diff = 218 grams; $p<0.0001$), shorter GA's (mean diff=0.5 weeks; $p<0.0001$), and receiving informal home care. Students of mothers with a previous PTB had a mean BW 638 grams lighter ($p<0.0001$), a mean GA 2.9 weeks shorter ($p<0.0001$), and a 50% greater odds of having received informal home care (OR=1.47; 95% CI: 1.23-1.78) compared to students of mothers with no report of a prior PTB.

Main Multivariate Findings

Aims 1 & 2: *To determine whether LBW and PTB are related to school readiness among Baltimore City kindergartners; and to determine whether prior care type moderates the relation between LBW, PTB and school readiness, adjusting for student and parent characteristics.*

Five sequential multivariate hierarchical linear regression models (HLM) estimated the effect of LBW and PTB on kindergarten school readiness scores, adjusted for the type of prior care the student received and other student and parent characteristics. Results for the LBW variables are presented in **Table 6.1** and PTB variables in **Table 6.2**. Findings for birth weight are discussed first followed by those for gestational age.

The findings supported the bivariate analyses which showed a significant difference in mean composite readiness scores between NBW students and those of different LBW categories. Model 0 showed that after controlling for clustering of readiness scores within cohort years and schools, students born NBW had mean readiness scores that were well above the 70 point cut-off for a ‘fully ready’ for school readiness assessment. Students born ELBW had mean readiness scores 6.82 points lower than NBW students ($p<0.001$), which suggested that on average ELBW students were not ‘fully ready’ at school entry. This adjusted difference in mean readiness scores for ELBW compared to NBW students was fourteen percent lower than the unadjusted mean readiness score difference between the two groups. Students born VLBW had mean readiness scores 2.62 points lower than NBW students ($p<0.001$), and those born MLBW had mean readiness scores 1.48 points lower than NBW students ($p<0.001$). The unadjusted difference in mean readiness scores between NBW and VLBW and MLBW students was five and thirteen percent greater than the adjusted model 0 estimated differences. Tests of the linear slopes (coefficients) confirmed that each LBW category was statistically significantly different from each other ($p<0.001$) as well.

Controlling for gestational age in model 1 resulted in the statistically significant difference in mean readiness scores between VLBW and NBW students to disappear. The differences in mean readiness scores between MLBW, ELBW and NBW students were smaller, but remained statistically significant ($p<0.001$). When prior care was included in model 2, students who were born NBW, full-term, and attended a district PK program had mean readiness scores equal to 77.7 points ($p<0.001$). Model 2 also showed an increase in the difference in mean readiness scores between ELBW and NBW students by 3.3%, but a decrease in the difference in mean readiness scores between MLBW and NBW students by 8.6% as compared to model 1 estimated differences.

The influence of student characteristics on the estimates for birth weight and gestational age and school readiness was examined in model 3 where prior care setting was not included. Compared to the coefficient estimates from model 1, with BW and GA categories only, the addition of student characteristics[h] resulted in decreases in mean readiness score differences between ELBW and NBW students by 4.0%, while the readiness gap between MLBW and NBW students increased by 39.2%. Mean readiness scores for students born VLBW were 1.31 points lower than for NBW students, a statistically significant difference ($p<0.05$), unlike in model 1.

[h] Student characteristics include race, age at school entry, FARMS status, SWD status, gender, number of siblings, multiple birth, low Apgar scores, abnormal newborn conditions of anemia and assisted ventilation, and fetal distress during labor.

The effect of parent characteristics[i] was estimated in model 4, again without controlling for prior care settings. The mean readiness score gap between MLBW and NBW students was -1.02 points ($p<0.001$), a decrease of 15.5% from the mean readiness score difference observed in model 3. The difference in mean readiness scores between VLBW, ELBW and NBW students increased by 4.7% and 1.9%, respectively. The difference in mean readiness scores between VLBW and NBW students was -1.51 points ($p<0.05$), but the difference in mean readiness scores between students born ELBW and NBW remained the largest, with a 4.42 point deficit for students born ELBW ($p<0.001$).

The estimated impact of prior care setting on the adjusted relation between student characteristics and school readiness was substantial based on model 5 results. Only statistically significant ($p<0.05$) student and parent characteristics from models 3 and 4 were included in model 5. Results indicate that adjusting for all other student and parent characteristics and the type of prior care received, ELBW students had mean composite readiness scores nearly 5 points lower than NBW students ($p<0.001$). Students born MLBW and VLBW had mean composite readiness scores that were 0.98 ($p<0.001$) and 1.30 ($p<0.05$) points lower than NBW students as well. The LBW category most influenced by the addition of the type of prior care into the model was students born VLBW. The addition of prior care to the model resulted in a 14.0% decrease in the mean readiness score difference between VLBW and NBW students. The impact of prior care settings on the differences in mean readiness scores of MLBW and NBW students was minimal and essentially non-existent among students born ELBW. Significantly different estimated LBW coefficients in model 5 were observed between MLBW and ELBW

[i] Parent characteristics include maternal race, maternal age, maternal years of education, marital status, maternal tobacco use, and missing paternal information.

($p<0.001$) and VLBW and ELBW ($p<0.01$) students only; the adjusted mean readiness scores of MLBW and VLBW students were not significantly different.

Table 6.1 Multivariate estimated differences in mean composite school readiness scores and standard errors of Baltimore City born kindergartners, 2002 to 2012, by birth weight categories

	Model 0	Model 1	Model 2	Model 3	Model 4	Model 5
Intercept	75.4 (0.92)***	75.6 (0.92)***	77.7 (0.83)***	74.9 (0.92)***	77.2 (0.92)***	79.1 (0.81)***
Birth weight (ref: NBW)						
MLBW	-1.48 (0.19)***	-0.86 (0.24)***	-0.79 (0.23)***	-1.20 (0.24)***	-1.01 (0.24)***	-0.97 (0.23)***
VLBW	-2.62 (0.53)***	-0.92 (0.67)	-0.76 (0.66)	-1.43 (0.66)*	-1.51 (0.66)*	-1.29 (0.64)*
ELBW	-6.82 (0.64)***	-4.52 (1.12)***	-4.67 (1.09)***	-4.33 (1.09)***	-4.42 (1.09)***	-4.43 (1.06)***

ref: reference category. Presented are regression coefficients with standard errors in parenthesis.
NBW: normal birth weight (≥2500 grams). MLBW: moderately LBW (1500-2499 grams). VLBW: very LBW (1000-1499 grams). ELBW: extremely LBW (<1000 grams).
All models include a random intercept for cohort years and school, and a cohort year time period indicator in the regression model.
Model 0: adds birth weight categories
Model 1: adds gestational age to model 0
Model 2: adds prior care setting to model 1
Model 3: includes model 1 plus student characteristics except prior care setting: student's race, gender, age, disability status, free and reduced meal plan (FARMS) status, number of siblings at birth, multiple birth, neonatal assisted ventilation, fetal distress, and low Apgar scores.
Model 4: includes model 3 plus parent characteristics: maternal and paternal race, maternal age, maternal years of education, marital status, maternal tobacco use, and missing paternal information.
Model 5: includes significant variables from model 4 plus prior care setting.
*p < 0.05 **p < 0.01 ***p < 0.001

Mean readiness scores also varied significantly by gestational age, adjusted for other student and parent characteristics (**Table 6.2**). In the empty model 0 which controlled for student cohort year and school clusters, students not born full-term had significantly lower mean readiness scores in each category of gestational age examined. Students born EPTB had the lowest mean readiness scores, 6.47 points lower than full-term students ($p<0.001$), followed by VPTB whose mean readiness scores were 2.91 points lower than readiness scores of students born full-term ($p<0.001$). Students born post-term also had mean readiness scores that were 1.87 points lower than students born full-term ($p<0.01$). The post-term difference in mean readiness scores was larger than the readiness gap of students born MPTB relative to full-term students. MPTB students' mean readiness scores were 1.17 points lower than full-term students ($p<0.001$), but they were not statistically different from post-term students. Students born early-term also had mean readiness scores 0.64 points lower than those born full-term ($p<0.001$).

Similar to the effect of gestational age on mean readiness score differences between birth weight categories, differences between gestational age categories were smaller but still statistically significant, adjusted for student's birth weights in model 1. The addition of the type of prior care to the model reduced the differences in gestational age mean readiness scores in model 2. Mean readiness score differences between full-term students and those born in each gestational age category ranged from -0.55 points for students born early-term ($p<0.001$) to -2.17 points for students born VPTB ($p<0.0001$). The difference in mean readiness scores between EPTB and full-term students was no longer statistically significant in model 2.

In model 3, type of prior care was excluded but other student characteristics were included as covariates. Again, differences in mean readiness scores between full-term and other gestational age categories were reduced. Compared to the estimated mean readiness score differences in model 1, the addition of student characteristics resulted in a 36.5% decrease in the estimated readiness gap between VPTB and full-term students. Adjusting for parent characteristics in model 4 did not have a substantial impact on mean readiness score differences across most gestational age categories. The estimated readiness score difference between MPTB and full-term students was no longer statistically significant with the addition of parent characteristics to the model, however.

Adjusting for students' type of prior care in model 5 had a substantial impact on the mean readiness scores of students born VPTB. In model 4, students born VPTB had mean readiness scores that were 1.14 points lower than full-term students ($p<0.01$). In model 5, the difference in mean readiness scores declined by 14.4% to a mean readiness score gap of -0.98 points between VPTB and full-term students ($p<0.05$). The estimated mean scores of each gestational age categories were not significantly different from each other in fully adjusted model 5.

Table 6.2 Multivariate estimated differences in mean composite school readiness scores and standard errors of Baltimore City born kindergartners, 2002 to 2012, by gestational age categories

	Model 0	Model 1	Model 2	Model 3	Model 4	Model 5
Intercept	75.6 (0.92)***	75.6 (0.92)***	77.7 (0.83)***	74.9 (0.92)***	77.2 (0.92)***	79.1 (0.81)***
Gestational age (ref: Full-term)						
Early-term	-0.64 (0.14)***	-0.57 (0.14)***	-0.55 (0.14)***	-0.45 (0.14)**	-0.45 (0.14)**	-0.44 (0.14)**
Post-term	-1.87 (0.68)**	-1.88 (0.68)**	-1.68 (0.66)*	-1.68 (0.66)*	-1.54 (0.65)*	-1.42 (0.64)*
MPTB	-1.17 (0.21)***	-0.76 (0.24)**	-0.66 (0.23)**	-0.50 (0.24)*	-0.45 (0.23)	-0.37 (0.23)
VPTB	-2.91 (0.33)***	-1.92 (0.44)***	-1.72 (0.43)***	-1.22 (0.43)**	-1.15 (0.43)**	-0.98 (0.42)*
EPTB	-6.47 (0.65)***	-2.74 (1.14)*	-2.17 (1.11)	-1.45 (1.12)	-1.31 (1.11)	-0.84 (1.08)

ref: reference category. Presented are regression coefficients with standard errors in parenthesis.
Full-term: 39 - 41 weeks Post-term: 42+ weeks. Early-term: 37-38 weeks. PTB: preterm birth, 37 weeks. MPTB: moderately PTB, 34 - 36 weeks. VPTB: very PTB, 28-33 weeks. EPTB: extremely PTB, <28 weeks.
All models include a random intercept for cohort years and school, and a cohort year time period indicator in the regression model.
Model 0: adds gestational age categories
Model 1: adds birth weight to model 0
Model 2: adds prior care setting to model 1
Model 3: includes model 1 plus student characteristics except prior care setting: student's race, gender, age, disability status, free and reduced meal plan (FARMS) status, number of siblings at birth, multiple births, neonatal assisted ventilation, fetal distress, and low Apgar scores.
Model 4: includes model 3 plus parent characteristics: maternal and paternal race, maternal age, maternal years of education, marital status, maternal tobacco use, and missing paternal information.
Model 5: includes significant variables from model 4 plus prior care setting.
*p < 0.05 **p < 0.01 ***p < 0.001

Student characteristics

A description of the unadjusted and adjusted mean composite readiness score differences observed between students' characteristics are provided in **Table 6.3**. The largest model 0 gaps in school readiness were observed between students with disabilities (SWD, β = -8.65; p<0.001) and general education students and between informal home care (β = -6.62; p<0.001) or family child care (β = -6.23; p<0.001) students and those who attended a district PK program.

Students who attended a district PK program had significantly higher mean readiness scores than all other prior care types except for students who attended a private nursery PK program, based on model 0 results. Adjustment for other student and parent characteristics (model 5) revealed that district PK students had the highest mean readiness scores of all prior care types. Each prior care coefficient was significantly different from the others, except for the estimated mean readiness score differences between informal home care and family child care and between other PK programs and private nursery PK programs.

NH White students had significantly higher readiness scores than NH Black students in model 0 while scores of Hispanic students were significantly lower than NH Black students. This racial gap in school readiness scores persisted when adjusted for other student characteristics in model 1a. It disappeared once adjusted for all other significant covariates in model 5, however.

Students who did not enter school as a five year old had significantly lower adjusted mean readiness scores in all models. Non-FARMS students had significantly higher mean readiness scores than FARMS students in each model as well. No difference in mean readiness scores was observed between students with one sibling and those with no siblings at birth in both models 0 and 1a. Adjustment for all other covariates in model 5 showed that first born students had significantly higher mean readiness scores than those with one ($p<0.01$) or two or more ($p<0.001$) siblings.

Students born of multiple gestation pregnancies had lower mean readiness scores in model 0 ($p<0.05$), but no difference in mean readiness scores was observed in model 1a. In model 5, adjusting for all other covariates showed twins and other multiples had significantly higher mean readiness scores than singleton births ($p<0.05$).

In each model considered, students with a low one-minute Apgar score had significantly lower mean readiness scores than students with high (≥ 7) one-minute Apgar scores; but the coefficients were smaller in models 1a and 5. Students with a low five-minute Apgar score had significantly lower model 0 and model 1a readiness scores ($p<0.001$ and $p<0.05$, respectively), but no significant difference in readiness scores was observed in model 5. In model 5, students who experienced fetal distress during labor had significantly lower mean readiness scores than those who did not, adjusted for all other covariates. Interestingly, students who received neonatal assisted ventilation had significantly lower mean readiness scores in model 0 ($p<0.05$), but higher adjusted mean readiness scores in model 5, than those who did not receive assisted ventilation ($p<0.05$).

Newborn anemia was associated with school readiness scores in the bivariate analysis, but controlling for cohort year and student school clusters in model 0 revealed no significant difference in mean readiness scores by newborn anemia status; it was therefore not included in further regression models.

Table 6.3 Multivariate estimated differences in mean composite school readiness scores and standard errors of Baltimore City born kindergartners, 2002 to 2012, by student characteristics

	Model 0	Model 1a	Model 5
Intercept		74.67 (0.92)***	79.1 (0.81)***
Prior care type (ref: district PK)			
Private nursery PK	-0.23 (0.44)		-1.62 (0.43)***
Other PK	-2.01 (0.28)***		-2.25 (0.27)***
Head Start	-3.49 (0.20)***		-3.30 (0.19)***
Child care center	-3.68 (0.30)***		-4.26 (0.29)***
Family child care	-6.23 (0.38)***		-6.25 (0.37)***
Informal home care	-6.62 (0.16)***		-6.46 (0.16)***
Female	3.36 (0.12)***	2.93 (0.12)***	2.84 (0.12)***
Race/Ethnicity (ref: NH Black)			
NH White	0.87 (0.29)**	0.73 (0.28)**	-0.01 (0.45)
Hispanic	-1.14 (0.39)**	-1.23 (0.38)**	-1.04 (0.53)
NH Asian	0.72 (1.00)	0.31 (0.97)	-1.16 (1.09)
NH Other	0.00 (1.08)	-0.21 (1.05)	-0.47 (1.04)
Age at school entry (ref: five)			
< 5	-1.93 (0.26)***	-2.09 (0.25)***	-2.04 (0.24)***
6+	-5.13 (0.67)***	-4.98 (0.65)***	-1.87 (0.64)**
Non-FARMS	1.66 (0.18)***	1.48 (0.18)***	0.87 (0.18)***
Disability status (ref: no disability)			
SWD	-8.65 (0.23)***	-8.02 (0.23)***	-8.34 (0.22)***
Missing	0.47 (0.48)	0.51 (0.47)	1.73 (0.46)***
Number siblings (ref: none)			
One	-0.17 (0.15)	-0.05 (0.15)	-0.47 (0.15)**
Two or more	-1.29 (0.15)***	-1.08 (0.15)***	-1.09 (0.17)***
Missing	-1.01 (1.07)	-0.88 (1.04)	-1.24 (1.01)
Multiple birth	-0.73 (0.34)*	-0.07 (0.33)	0.84 (0.34)*
One-minute Apgar score (ref: scores ≥7)			
Low	-1.22 (0.21)***	-0.75 (0.22)***	-0.43 (0.21)*
Missing	0.31 (1.03)	-3.46 (3.44)	-2.65 (3.34)
Five-minute Apgar score (ref: scores ≥7)			
Low	-2.28 (0.51)***	-1.11 (0.54)*	-0.26 (0.53)
Missing	0.68 (1.06)	4.53 (3.55)	4.05 (3.44)
Fetal distress	-0.92 (0.33)**	-0.61 (0.32)	-0.63 (0.31)*
Assisted ventilation	-1.48 (0.63)*	0.12 (0.63)	1.46 (0.63)*
Newborn anemia	-1.83 (1.96)		

ref: reference category. Presented are regression coefficients with standard errors in parenthesis.
All models include a random intercept for cohort years and school, and a cohort year time

period indicator in the regression model.
Model 0: models each variable separately
*Model 1a: includes all variables shown, except prior care type.
Model 5: includes significant student and parent variables plus gestational age and birth weight categories.
*p < 0.05 **p < 0.01 ***p < 0.001

Parent characteristics

Individual parent characteristics associated with student school readiness scores are shown in **Table 6.4**. Significant differences in mean readiness scores were observed between NH White and Hispanic mothers and fathers and NH Black mothers and fathers in model 0. Controlling for all other parent characteristics in model 1b, a majority of the differences in mean readiness scores between maternal race categories were no longer significant, but students of NH White fathers still had significantly higher mean readiness scores than students of NH Black fathers ($p<0.05$). In the final adjusted model 5, the paternal racial readiness gaps disappeared, although the NH White – NH Black maternal race difference in mean readiness scores was statistically significant.

Students of teenage mothers (<20) had significantly lower mean readiness scores in model 0, but controlling for all other covariates in model 5 resulted in no significant difference in mean readiness scores by maternal age. Maternal years of education showed the most consistent relation of the parent indicators with students' school readiness. Kindergarten students of mothers with 13 or more years of education had the highest mean readiness scores in each model. Students of mothers with less than 12 years of education had significantly lower mean readiness scores than those of students with mothers with 12 years of education ($p<0.001$).

Mean readiness scores of students with mothers who reported smoking during pregnancy had significantly lower adjusted mean readiness scores ($p<0.01$). Students whose parents were married at birth had significantly higher adjusted mean readiness scores than students whose parents were not married ($p<0.001$). Students with no paternal information (age, education, and nativity) reported on their birth certificate had significantly lower adjusted mean readiness scores in model 5.

Maternal report of a previous PTB was associated with lower mean readiness scores in model 0, but controlling for other parent characteristics diminished the relation. It was not explored further in the analysis. Similarly, students of foreign born mothers had significantly higher mean readiness scores in bivariate analyses, but once adjusted for student cohort year and school clusters in model 0 the significant difference in mean readiness scores disappeared.

Table 6.4 Multivariate estimated differences in mean composite school readiness scores and standard errors of Baltimore City born kindergartners, 2002 to 2012, by parent characteristics

	Model 0	Model 1b	Model 5
Intercept		77.4 (0.93)***	79.1 (0.81)***
Maternal race (ref: NH Black)			
NH White	0.72 (0.27)**	0.36 (0.35)	0.85 (0.40)*
Hispanic	-1.04 (0.43)*	-0.78 (0.44)	-0.23 (0.58)
Asian	4.62 (2.29)*	3.01 (3.21)	2.56 (3.06)
NH Other	1.02 (0.70)	0.56 (0.79)	1.08 (0.78)
Missing	-2.38 (2.89)	-2.94 (2.89)	-3.12 (2.74)
Paternal race (ref: NH Black)			
NH White	1.18 (0.30)***	0.76 (0.38)*	0.48 (0.40)
Hispanic	-0.91 (0.14)***	0.18 (0.21)	0.22 (0.20)
Asian	4.87 (2.75)	1.53 (3.85)	2.82 (3.73)
NH Other	0.31 (0.73)	-0.29 (0.83)	-0.51 (0.80)
Missing	-0.43 (0.55)	0.50 (0.57)	0.56 (0.54)
Maternal age (ref: 20 - 35)			
< 20	-0.41 (0.14)**	0.54 (0.15)***	-0.07 (0.17)
36+	-0.09 (0.26)	-0.40 (0.26)	0.08 (0.25)
Missing	-4.50 (3.16)	-4.11 (3.16)	-4.64 (3.00)
Maternal years of education (ref: 13+ years)			
12 years	-2.22 (0.17)***	-2.07 (0.18)***	-1.56 (0.17)***
< 12 years	-4.11 (0.18)***	-3.90 (0.20)***	-3.03 (0.19)***
Missing	-2.70 (0.49)***	-2.53 (0.50)***	-1.61 (0.48)***
Married	1.50 (0.17)***	0.53 (0.19)**	0.58 (0.18)**
Maternal tobacco use (ref: none)			
Yes	-1.79 (0.18)***	-1.20 (0.19)***	-0.57 (0.18)**
Missing	1.23 (1.19)	1.43 (1.19)	1.16 (1.13)
Missing paternal information	-1.21 (0.14)***	-0.72 (0.21)***	-0.64 (0.20)**
Previous PTB	-1.30 (0.53)*	-0.99 (0.53)	
Maternal nativity (ref: US born)			
Foreign born	-0.02 (0.29)		
Missing	-1.21 (0.74)		

ref: reference category. Presented are regression coefficients with standard errors in parenthesis.
All models include a random intercept for cohort years and school, and a cohort year time period indicator in the regression model.
Model 0: models each variable separately
*Model 1: includes all variables shown.
Model 5: includes significant student and parent variables plus gestational age and birth weight categories.
*p < 0.05 **p < 0.01 ***p < 0.001

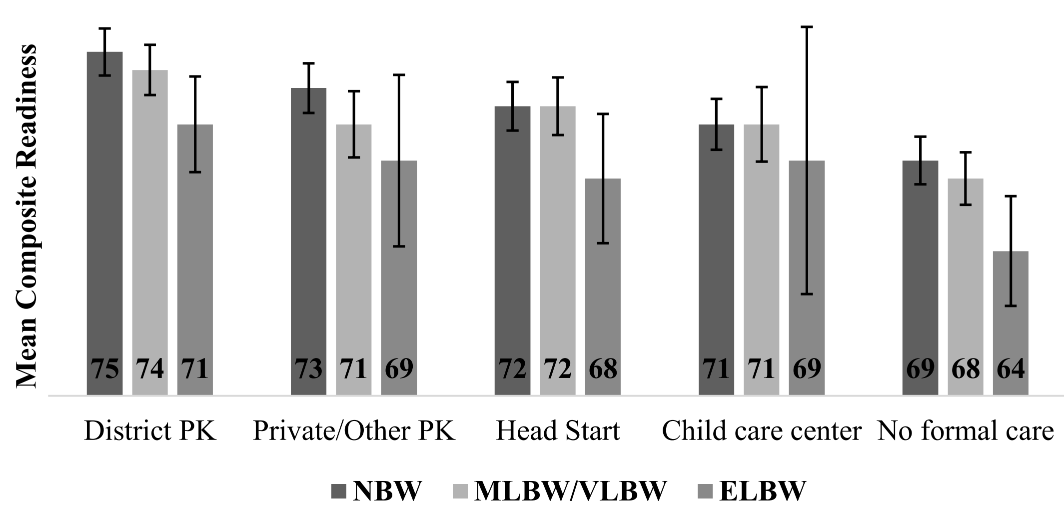
Interaction terms

To test whether mean readiness scores of LBW and PTB students varied by the type of prior care, interaction terms for LBW, PTB, and prior care setting variables were entered into the regression model that included all model 5 covariates. A statistically significant interaction between students born MLBW and those who attended other PK programs was observed ($p<0.01$).

To better understand this interaction between birth weight and prior care setting, LBW and prior care categories with similar adjusted mean readiness scores in model 5 were combined to increase the power to detect non-spurious statistical interactions. In other words, categories were combined to minimize the probability of detecting a type I (incorrectly rejecting the null hypothesis) or II (failing to correctly reject the null hypothesis) error. MLBW and VLBW were combined to represent students born weighing 1000 – 2499 grams (MLBW/VLBW). Students who attended a private nursery PK and those who attended another PK program were combined to represent private/other PK programs, and students who received informal and family child care were combined to represent no formal prior care.

Figure 8.1 shows adjusted mean readiness scores of the combined birth weight and prior care setting groups. Readiness scores within birth weight groups varied significantly by the type of prior care. Among students born ELBW, those who had no formal prior care had significantly lower mean readiness scores than students born ELBW who attended a district PK program ($p<0.0001$). No other formal setting appeared to have an impact on readiness scores of ELBW students. Among students born MLBW/VLBW, those who attended a district PK program had mean readiness scores that were significantly higher than readiness scores of MLBW/VLBW students who received prior care in any other setting. Readiness scores of MLBW/VLBW students who attended private/other PK programs, a Head Start program, or a child care center did not differ. Among NBW students, mean readiness scores were significantly higher for students who attended a district PK program; the scores of those who attended a child care center did not differ from scores of NBW students who received no formal care (p=0.2225). The profound effect of ELBW on school readiness is further highlighted by the markedly lower readiness scores of students born ELBW who received no formal care compared to those born NBW who attended district PK programs.

Figure 8.1 Adjusted mean composite readiness scores and 95% confidence intervals of Baltimore City kindergartners, 2002 to 2012, by birth weight and prior care setting

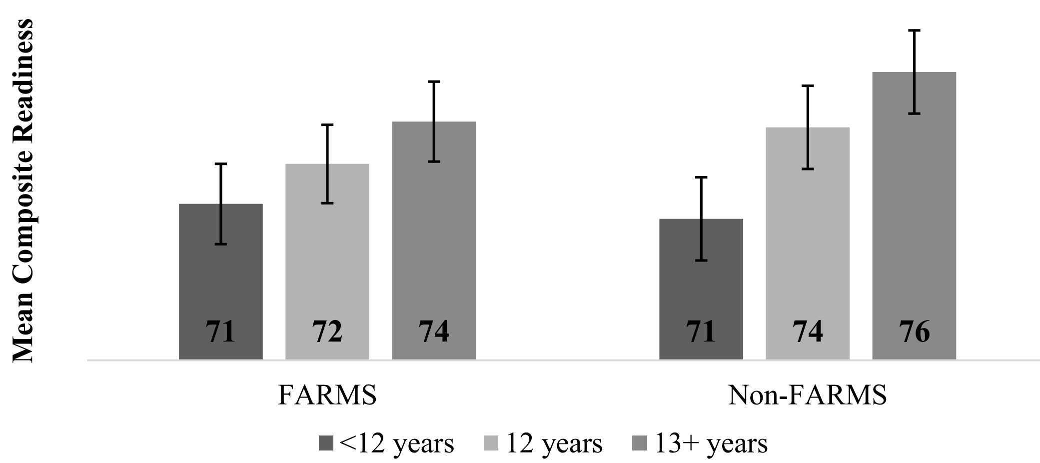


PK: prekindergarten NBW: normal birth weight, ≥2500 g
MLBW: moderately low birth weight, 1500-2499 g VLBW: very low birth weight, 1000-1499 g
ELBW: extremely low birth weight, <1000 g. Adjusted for model 5 covariates.

Studies show that maternal education (Hillemeier, 2011; Isaacs, 2011), socioeconomic status (Hillemeier, 2011; Isaacs, 2011; Beaino, 2011), and maternal smoking (Moore, 2014) are related to school readiness. Results from model 5 show that readiness scores are significantly higher for mothers with more years of education, for students from higher income families as defined by FARMS status at school entry, and for students whose mothers did not smoke during pregnancy. We tested whether readiness scores of LBW and PTB students varied significantly by each measure, adjusting for model 5 covariates, but no significant interaction was observed (p>0.01).

Readiness scores of FARMS students did vary significantly by years of maternal education. Non-FARMS status was associated with higher adjusted mean readiness scores in model 5. However, non-FARMS students of mothers with less than twelve years of education had significantly lower mean readiness scores than non-FARMS or FARMS students of mothers with 13 or more years of education, adjusted for other student and parent characteristics (**Figure 8.2**).

Figure 8.2 Adjusted mean composite readiness scores and 95% confidence intervals of Baltimore City kindergartners, 2002 to 2012, by FARMS status and



FARMS: free and reduced price meals

Model diagnostics

An assessment of how well the constructed models explained the relation between each group of variables and school readiness scores is provided in **Table 6.5**. Model 0 with only birth weight categories explained 0.5% of the variation in school readiness scores. Gestational age alone explained slightly more of the variation, but was still only 0.6%. Type of prior care alone explained almost 4.6% of readiness score variation. Nearly six percent (5.9%) of the variation in readiness scores was explained by student characteristics, the highest of all variable groups considered. Parent characteristics explained 1.7% of the readiness score variation, and the final adjusted model 5 explained a total of 11.9% of the variation in school readiness scores in the study sample. Variables that best explained readiness score variation in model 5, in order, were prior childcare type (4.8%), student disability status (4.2%), gender (1.2%), maternal education (0.7%), student age (0.3%), and then student birth weight (0.1%). The inclusion of statistically significant interaction terms in model 6 explained about 0.1% more of the variation in readiness scores, relative to model 5.

In each model, the random intercept for schools explained about eight percent of the variance in readiness scores while the random intercept for cohort years explained about three percent. Both random intercepts were statistically significant in each model. Lower AIC values help identify the best fit regression model among nested models, and the lowest AIC value observed was for model 6 that included variables from the fully adjusted model 5 plus interaction terms. The appropriateness of the model was further confirmed by normally distributed residuals around a mean of zero from the final model 5, as assumed by the model.

Table 6.5 Regression model fit statistics from multivariate regressions estimating the differences in mean composite school readiness scores of Baltimore City born kindergartners, 2002 to 2012

Model iteration	Readiness score variance explained by model, %	AIC	Variance explained by school random intercept, %	Variance explained by cohort year random intercept, %
Model 0: BW only	0.5	309903.6	8.62***	3.48*
Model 0: GA only	0.6	309893.8	8.60***	3.47*
Model 0: PC type only	4.6	308282.6	9.28***	2.78*
Model 1: BW + GA	0.6	309866.0	8.59***	3.47*
Model 1a: Student variables	5.9	307792.8	8.16***	3.65*
Model 1b: Parent variables	1.7	309439.6	8.48***	3.52*
Model 2: BW + GA + PC type	5.1	308084.2	9.19***	2.81*
Model 3: BW + GA + Student variables	6.2	307637.5	8.15***	3.68*
Model 4: BW + GA + Student + Parent variables	7.5	307068.1	8.18***	3.62*
Model 5: BW + GA + Student + Parent + PC type	11.9	305272.3	8.66***	2.77*
Model 6: BW + GA + Student + Parent + PC type + Interaction terms	12.0	305238.5	8.66***	2.75*

BW: birth weight categories. GA: gestational age categories. PC: prior care type. AIC: Akaike Information Criterion. BIC: Bayesian information criterion

Student variables: student's race, gender, age, disability status, free and reduced meal plan (FARMS) status, number of siblings at birth, multiple births, neonatal assisted ventilation, fetal distress, and low Apgar scores.

Parent variables: maternal and paternal race, maternal age, maternal years of education, marital status, missing paternal information, and maternal tobacco use.

Interaction terms: MLBW x other PK & non-FARMS x maternal ed <12 yrs.

*p < 0.05 **p < 0.01 ***p < 0.001

Sensitivity Analysis

To account for the skewed distribution of composite readiness scores, all covariates from the adjusted model 5 were input into a generalized estimating equation to model the log-odds of students receiving a low (<60) composite readiness score compared to those receiving higher (≥ 60) readiness scores. Results from this model revealed that students born VLBW did not have an increased adjusted odds of receiving a low composite readiness score (adjusted OR (AOR) = 1.13, 95% CI: 0.83 - 1.54) compared to NBW students, although they had significantly lower mean readiness scores than NBW students (model 5 β= -1.30, $p<0.05$). Similarly, students born early-term, post-term, and VPTB had significantly lower mean readiness scores, but showed no significant increased adjusted odds for low readiness scores. Students who attended a private nursery PK program had significantly lower mean readiness scores than district PK students, but they did not have an increased odds of low composite readiness scores.

Other variables with an observed statistically significant difference in mean readiness scores but no increased odds of low readiness scores include: students with one sibling, multiple births, students who experienced fetal distress, received neonatal assisted ventilation, and students of NH White mothers. Of note, mean readiness scores of NH Asian students did not differ significantly from mean readiness scores for NH Black students, but NH Asian students had an increased adjusted odds of low readiness scores (AOR = 1.76, 95% CI: 1.05 – 2.97). The interaction between MLBW and other PK attendance ($p<0.0001$) and between maternal education less than 12 years and non-FARMS status ($p=0.0019$) were statistically significant in the log-odds model as well.

Mean readiness scores were significantly higher for students in cohorts that entered school in 2006 and after compared to earlier cohorts. The variables included in the final adjusted model 5 were re-run stratified by cohort year to examine whether the observed LBW and PTB adjusted mean readiness score differences varied significantly over time. Results showed that students born MLBW had significantly lower adjusted mean readiness scores than NBW students in 2003 (β = -2.44; $p=0.0039$) and 2012 (β = -1.81; $p=0.0029$) only. Students born ELBW had significantly lower adjusted mean readiness scores than NBW students in 2005 (β = -10.07; p=0.0038), 2008 (β = -8.84; p=0.0073), and 2013 (β = -8.32; p=0.0028). Adjusted mean readiness scores were significantly lower than students born full-term only for early-term (β = -1.24; p=0.0058) and VPTB (β = -3.98; p=0.0027) students in 2004 and for post-term students in 2010 (β = -7.16; p=0.0074).

Domain readiness differences

Prior to examining the adjusted difference in mean standardized domain readiness scores, inter-domain correlations were computed to assess how well the domains could be differentiated (**Table 7**). Domain readiness scores were highly correlated, with the highest correlation observed between the mathematical thinking and language & literacy domain (r = 0.86) and the lowest between the scientific thinking and physical development & health domain (r = 0.55). In general, the arts domain had the lowest correlation with any other domain while standardized scores in the language & literacy domain were most consistently correlated with other domains.

Table 7. Inter-school readiness domain Pearson correlation coefficients of the final study sample of Baltimore City born kindergartners, 2002 to 2012

Readiness Domain	Composite	Language & Literacy	Mathematical Thinking	Scientific Thinking	Social & Personal Development	Social Studies	The Arts
Language & Literacy	0.85						
Mathematical Thinking	0.83	0.86					
Scientific Thinking	0.79	0.75	0.77				
Social & Personal Development	0.75	0.69	0.63	0.57			
Social Studies	0.82	0.75	0.76	0.83	0.64		
The Arts	0.73	0.62	0.60	0.58	0.60	0.62	
Physical Development & Health	0.73	0.64	0.60	0.55	0.66	0.60	0.70

All correlations coefficients statistically significant, $p < 0.0001$.

Regression models were constructed to test whether the relation between LBW, PTB, prior care type and school readiness varied by readiness domains, adjusted for other significant student and parent characteristics. Different parameter estimates across domains may highlight areas of school readiness where students excelled or struggled. Model 5 covariates were included in regression models to estimate the difference in mean standardized domain readiness scores. To compare estimated mean differences across domains, 95% confidence intervals (CI) were also calculated.

Adjusted domain readiness models showed that the average student had adjusted mean standardized domain readiness scores that were higher than the cohort year mean. Students also had mean standardized language and literacy and mathematical thinking readiness scores that were higher than all other domains except the scientific thinking domain (**Appendices E, F, & G**).

Similar to the composite readiness models, significant differences were observed between LBW and PTB categories within domain areas, but not across domain areas due to overlapping 95% CIs. The domain readiness gaps between students born NBW and those in each LBW category was similar to that observed in the composite readiness score models. Students born ELBW had significantly lower mean readiness scores than MLBW students in each domain except the arts domain. Mean readiness scores of students born VLBW were not significantly different from MLBW students, adjusted for other covariates (**Appendix E**). The readiness gap between students born full-term and those in PTB categories resembled the differences observed in the composite model. Of note, students born EPTB had significantly lower mean standardized physical development and health readiness scores than full-term, early-term, and MPTB students, adjusted for all other covariates (**Appendix F**). No significant difference in adjusted mean composite readiness scores was observed for students born EPTB compared to full-term students, however (**Table 6.2**).

Mean readiness score differences between prior care types varied significantly within and across readiness domains. Similar to the composite model results, mean standardized domain readiness scores were highest for students who attended a district PK program prior to school entry as compared to all other prior care types, adjusted for other covariates (**Appendix G**). The difference in mean standardized domain readiness scores between district PK students and those from other prior care settings, except private nursery PK programs, were significantly greater in the language and literacy and mathematical thinking domains than in any of the other domains.

Aims 1 & 2 summary

In summary, the findings for Aims 1 & 2 show that indeed, LBW and PTB are associated with lower mean readiness scores in this population based sample of low-income, predominantly minority, Baltimore City kindergarten students. The type of prior care plays an important role in readiness as well. Students who attended a district PK program had the highest adjusted mean readiness scores. Results also indicate that readiness scores of LBW students vary significantly by the type of prior care received. Among ELBW students, only students who attended district PK had higher readiness scores than those of ELBW students who received informal home care. The findings provide further evidence of the intergenerational effects of maternal education as well. Students of mothers with fewer years of education had significantly lower adjusted mean readiness scores, even among non-FARMS students.

Neighborhood Analysis & Findings

Aim 3: *To determine whether Baltimore neighborhood characteristics modify the relation between LBW and PTB and school readiness, adjusting for parent and child characteristics at birth and prior care characteristics at school entry.*

A progression of five sequential multivariate HLMs was evaluated to estimate the effect of neighborhood characteristics on the relation between LBW and PTB and school readiness. A descriptive analysis of the neighborhood data is presented below followed by the multivariate results.

Univariate analysis

A description of the selected Baltimore Neighborhood Indicators Alliance (BNIA) data used to characterize the 55 Baltimore City neighborhoods is presented in **Table 8**. The mean healthy food availability index (HFAI) in 2012 was 10.5 across Baltimore neighborhoods, slightly higher than the mean HFAI estimated in the study by Franco et al (2008). Franco et al (2008) observed that HFAI values were lower in predominantly Black neighborhoods of Baltimore City and its surrounding counties. We did not include Baltimore's surrounding counties. Neighborhood HFAI values were not significantly correlated with the percentage of African American residents in 2010 ($r = -0.25$, $p=0.0631$), but a weak positive correlation was observed between HFAI values and the percentage of White neighborhood residents in 2010 ($r = 0.27$, $p=0.0468$). Mean neighborhood median household income (MHI) increased significantly from 2000 to 2010 (mean change = +$11,088.37, $p <0.0001$), according to US decennial census estimates. Nearly half of students in the final study sample (44.2%) had mothers who resided in neighborhoods with relatively low MHIs at birth. Mean HFAI values were significantly higher in neighborhoods with higher composite MHIs (F-stat = 3.5, p=0.0374). The majority of Baltimore City neighborhoods (52.7%) included female headed households (FHH) in 2010. The percentage of FHH varied significantly by neighborhood income level (F-stat = 27.1, p<0.0001). On average, FHH made up two-thirds of low income neighborhood households compared to just more than one-third in high income neighborhoods.

Table 8. Descriptive statistics of kindergartners' residential neighborhood characteristics at birth in the final study sample of Baltimore City born kindergartners, 2002 to 2012

			Neighborhood Income Level					
			Low		Medium		High	
		Number neighborhoods	19		17		19	
		Number students (%)	17,446 (44.2%)		12,960 (32.8%)		9,057 (22.9%)	
Indicator	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Healthy food availability index, 2012 (range: 0 to 27)	10.50	3.95	8.97	3.12	10.31	2.55	12.20	5.07
Female headed households, 2010 (%)	52.66	18.08	66.22	10.80	56.19	10.74	35.95	16.16
Median household income, 2000 ($)	30,804.59	11,150.03	20,446.70	3,943.17	29,229.05	3,014.25	42,572.17	9,358.69
Median household income, 2010 ($)	41,892.96	17,087.88	27,067.30	6,170.75	38,241.65	4,706.65	59,985.59	15,102.50

SD: standard deviation. N = 55 Baltimore neighborhoods. Mean values across neighborhood income levels for each characteristic were significantly different: HFAI F-stat=3.5, p=0.0374; FHH F-stat=27.1, p<0.0001; 2000 MHI F-stat=61.2, p<0.0001; 2010 MHI F-stat=53.7, p<0.0001.

Bivariate neighborhood analysis

The relation of neighborhood MHI, the healthy food availability index, and the percentage of FHH with mean neighborhood composite school readiness scores was explored with Pearson correlations and scatterplots (**Figures 9.1 to 9.4**). Mean readiness scores generally tended to be higher in neighborhoods with greater MHIs in both 2000 ($r = 0.69$, $p<0.0001$) and 2010 ($r = 0.61$, $p<0.0001$). Greater availability of healthy food in neighborhoods was also positively correlated with higher mean neighborhood readiness scores ($r = 0.43$, $p=0.0008$), although the correlation was less strong than for MHI. A greater percentage of FHHs at the neighborhood level was negatively correlated with mean readiness scores ($r = -0.41$, $p=0.0020$). The 2000 MHI explained a greater proportion of the variation in neighborhood mean readiness scores than other neighborhood characteristic ($R^2 = 0.46$); the percentage of FHH explained the least amount of variation in scores ($R^2 = 0.16$).

Figure 9.1 Mean neighborhood composite school readiness scores of Baltimore City kindergartners, 2002 to 2012, by neighborhood median household income, 2000

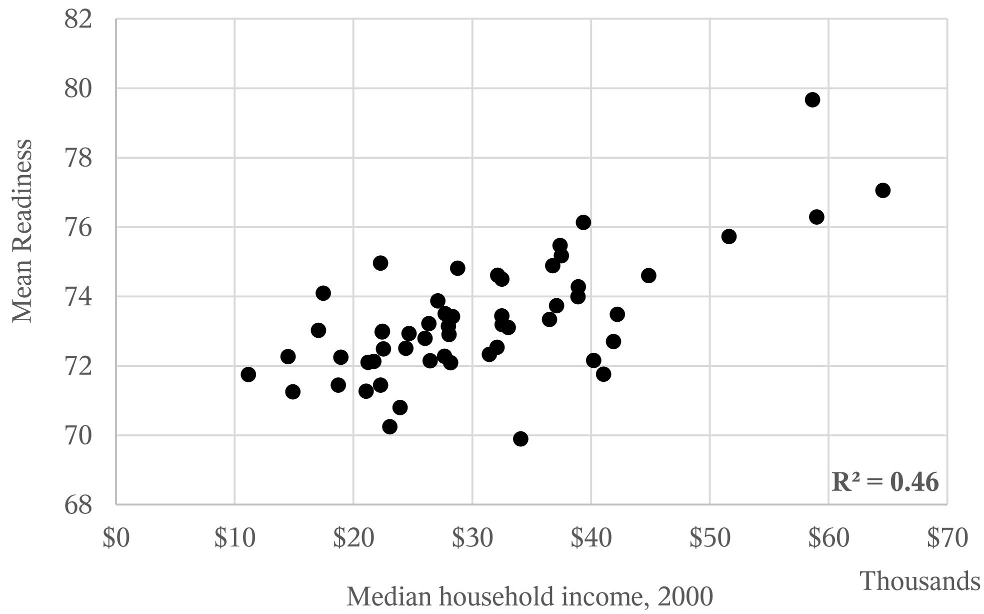


Figure 9.2 Mean neighborhood composite school readiness scores of Baltimore City kindergartners, 2002 to 2012, by neighborhood median household income, 2010

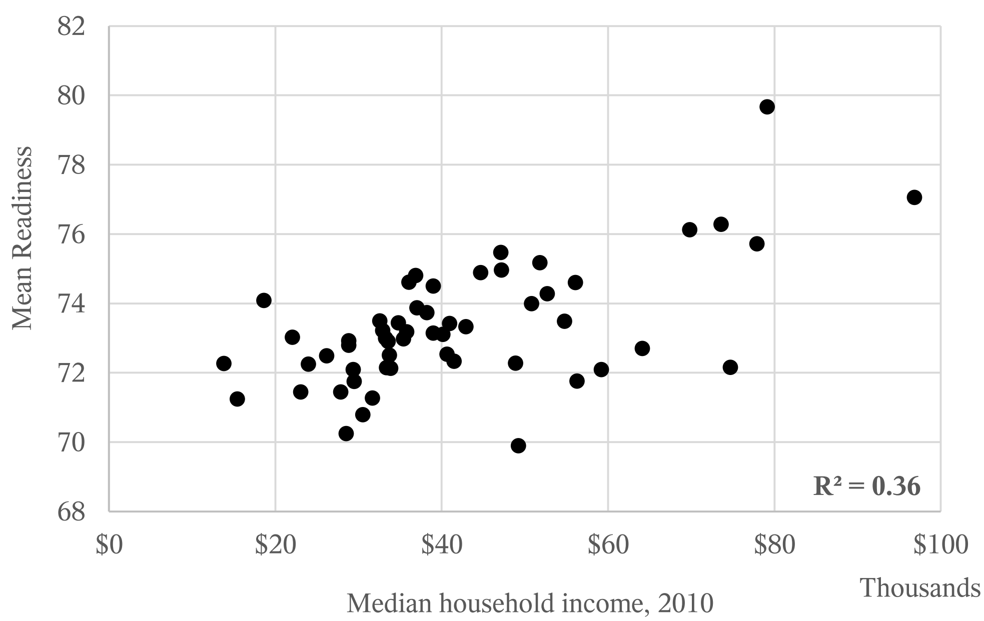


Figure 9.3 Mean neighborhood composite school readiness scores of Baltimore City kindergartners, 2002 to 2012, by the healthy food availability index, 2012

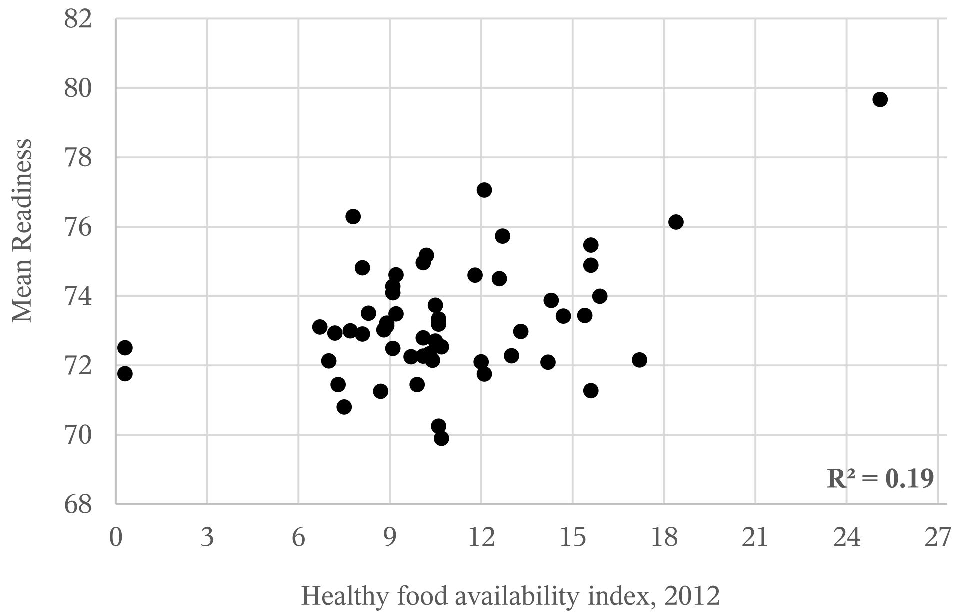
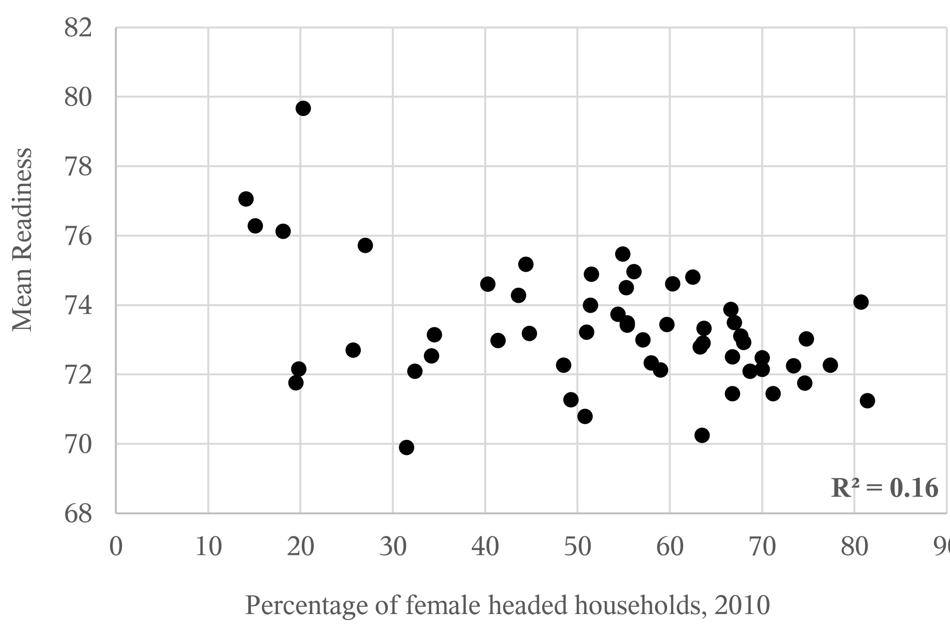


Figure 9.4 Mean neighborhood composite school readiness scores of Baltimore City kindergartners, 2002 to 2012, by the percentage of female headed households, 2010

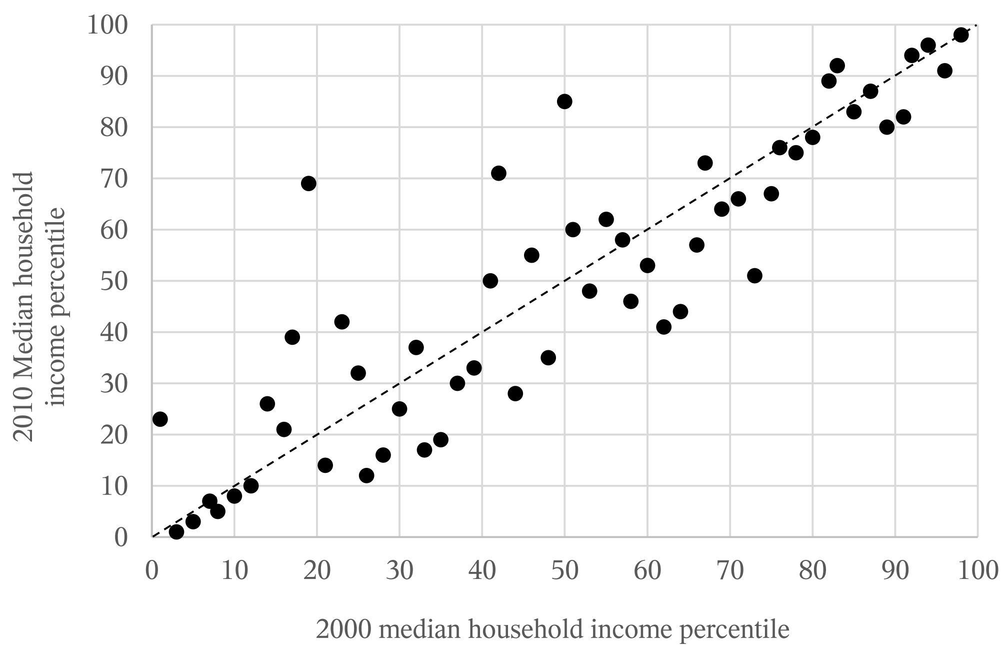


Average student birth weight and gestational age varied significantly by neighborhood economic levels. Mean birth weight in neighborhoods was strongly correlated with the 2000 MHI ($r = 0.58$, $p<0.0001$) and 2010 MHI ($r = 0.75$, $p<0.0001$), but only moderately correlated with healthy food availability in neighborhoods ($r = 0.31$, $p=0.0227$). A strong negative correlation between mean birth weights and the percentage of FHH was observed in 2010 ($r = -0.86$, $p<0.0001$). A greater percentage of students in low income neighborhoods were born MLBW (12.1%) than in medium (11.4%) or high (9.9%) income neighborhoods ($\chi^2 = 27.5$, $p<0.0001$). No significant difference in the percentage of VLBW and ELBW students was observed across neighborhood income levels.

Similarly, mean duration of pregnancy was longer in neighborhoods with higher median household income in 2000 ($r = 0.57$, $p<0.0001$) and 2010 ($r = 0.74$, $p<0.0001$). HFAI values were only moderately correlated with the mean neighborhood gestational age ($r = 0.33$, $p=0.0134$). Gestational ages were shorter in neighborhoods with greater percentages of FHH in 2010 ($r = -0.79$, $p<0.0001$). A greater proportion of students in low income neighborhoods were born early-term ($\chi^2 = 9.7$, $p=0.0077$), MPTB ($\chi^2 = 27.5$, $p<0.0001$), or VPTB ($\chi^2 = 13.0$, $p=0.0015$) than in medium and high income neighborhoods.

Interestingly, MHI increased by about $11,000 from 2000 to 2010 US Census, but relative neighborhood MHI levels actually declined. MHIs were converted to percentile ranks to estimate each neighborhood's relative MHI level. **Figure 9.5** shows that 56.4% (n = 31) of neighborhoods saw a decline in their relative income level from 2000 to 2010, while 36.4% (n=20) improved and 7.3% (n = 4) maintained the same position. Mean readiness scores of students in neighborhoods that did not change in relative income position from 2000 to 2010 were significantly higher than for students in neighborhoods with declines in the relative income position from 2000 to 2010 ($\beta = 1.22$, p=0.0003). No difference in mean readiness scores was found between students born in neighborhoods that declined in relative and those where improvements were observed.

Figure 9.5 Scatterplot of 2000 and 2010 neighborhood median household income percentile ranks.



Multivariate analysis

The effect of neighborhood characteristics on readiness scores and on the relation between LBW and PTB and school readiness was estimated with six sequential multivariate hierarchical linear regression models (HLM), adjusted for other student and parent characteristics. Results showed that higher neighborhood income, greater availability of healthy food and higher percentages of female headed households were independently associated with higher mean readiness scores. These neighborhood characteristics did not have a significant impact on the relation between LBW and PTB and school readiness.

Mean readiness scores of MLBW, VLBW, and ELBW students were significantly lower than NBW students, adjusting for student birth neighborhood and cohort year clusters in model 0 (**Table 9.1**). The unadjusted neighborhood effect on mean readiness score differences between NBW and LBW students was smaller than the school level effect observed in Aims 1 & 2. In the neighborhood model 0, MLBW students had mean readiness scores that were 1.59 points lower than NBW students ($p<0.001$), adjusted for neighborhood clusters and cohort year.

The impact of neighborhood characteristics was determined by comparing the estimated coefficients for each LBW category in model 4 to their estimated model 5 coefficient where neighborhood characteristics were included in the model. Little to no change was documented for the difference in mean readiness scores between students born in each LBW category relative to NBW students after neighborhood characteristics were included in the model. Model 6, which included a random intercept for school clusters, showed a substantial change in the coefficient estimates for VLBW and ELBW students, which suggests that the student's schools play a larger role in influencing the relation between LBW and school readiness. Slightly smaller standard errors were also observed when a random intercept for schools was included in the model, which suggests that adjusting for school clusters provides a more precise estimate of the difference in mean readiness scores between LBW and NBW students.

Table 9.1 Multivariate estimated differences in mean composite school readiness scores and standard errors of Baltimore City born kindergartners by neighborhood impact model progressions, 2002 to 2012, by LBW categories

Model Iteration	Intercept	LBW category (ref: NBW) MLBW	VLBW	ELBW
	β (SE)	β (SE)	β (SE)	β (SE)
0	75.92 (0.88)***	-1.59 (0.20)***	-2.50 (0.54)***	-7.40 (0.66)***
1	76.16 (0.88)***	-0.87 (0.25)***	-0.60 (0.69)	-4.98 (1.15)***
2	68.74 (1.64)***	-0.88 (0.25)***	-0.61 (0.69)	-4.96 (1.15)***
3	77.57 (0.77)***	-1.10 (0.24)***	-0.87 (0.66)	-4.71 (1.10)***
4	79.56 (0.76)***	-0.96 (0.24)***	-0.96 (0.66)	-4.78 (1.09)***
5	74.12 (1.51)***	-0.95 (0.24)***	-0.95 (0.66)	-4.72 (1.09)***
6	76.27 (1.21)***	-0.98 (0.23)***	-1.30 (0.64)*	-4.42 (1.06)***

ref: reference category. Presented are regression coefficients with standard errors in parenthesis.
NBW: normal birth weight (>2500 grams). MLBW: moderately LBW (1500-2499 grams).
VLBW: very LBW (1000-1499 grams). ELBW: extremely LBW (<1000 grams).
All models include a random intercept for cohort years and neighborhood, and a cohort year time period indicator in the regression model.
Model 0: adds birth weight categories
Model 1: adds gestational age to model 0
Model 2: includes model 1 plus neighborhood characteristics: 2000 MHI, 2012 HFAI, and 2010 FHH
Model 3: includes model 1 plus student characteristics: type of prior care, student's race, gender, age, disability status, free and reduced meal plan (FARMS) status, number of siblings at birth, multiple birth, neonatal assisted ventilation, fetal distress, and low Apgar scores.
Model 4: includes model 3 plus parent characteristics: maternal and paternal race, maternal age, maternal years of education, marital status, maternal tobacco use, and missing paternal information.
Model 5: includes significant variables from model 4 plus neighborhood characteristics.
Model 6: adds a random intercept for school to model 5.
*p < 0.05 **p < 0.01 ***p < 0.001

Neighborhood characteristics also had a minimal impact on the relation between gestational age and school readiness as well (**Table 9.2**). Controlling for neighborhood student clusters and cohort years in model 0 produced estimated mean readiness differences between students born full-term and those born at other gestational ages that were smaller than the unadjusted differences, but not as small as those observed when controlling for school clusters in Aims 1 & 2. In model 2 and model 5, where neighborhood characteristics were included as covariates, the change in the estimated mean readiness score differences was very small, suggesting that neighborhood income and healthy food availability had little influence on the relation between gestational age and school readiness. Model 6 showed that accounting for student school clusters had a larger impact on the observed relation between gestational age and school readiness than controlling for neighborhood clusters. The estimated coefficients for all gestational age categories changed substantially from model 5 to model 6, and the standard error estimates were slightly smaller for each category except for students born early-term. Again, these changes provide further evidence that adjusting for school clusters provides a better estimate of the relation between birth characteristics and school readiness than adjusting for neighborhood clusters alone.

Table 9.2 Multivariate estimated differences in mean composite school readiness scores and standard errors of Baltimore City born kindergartners by neighborhood impact model progressions, 2002 to 2012, by PTB categories

Model Iteration	Intercept	PTB category (ref: full-term)				
		Early-term	Post-term	MPTB	VPTB	EPTB
	β (SE)	β (SE)	β (SE)	β (SE)	β (SE)	β (SE)
0	76.14 (0.88)***	-0.64 (0.15)***	-2.07 (0.69)**	-1.34 (0.22)***	-3.07 (0.34)***	-6.88 (0.67)***
1	76.16 (0.88)***	-0.56 (0.15)***	-2.08 (0.69)**	-0.92 (0.25)***	-2.13 (0.46)***	-2.85 (1.17)*
2	68.74 (1.64)***	-0.56 (0.15)***	-2.09 (0.69)**	-0.91 (0.25)***	-2.12 (0.46)***	-2.86 (1.17)*
3	77.57 (0.77)***	-0.41 (0.14)**	-1.69 (0.66)*	-0.56 (0.24)*	-1.23 (0.44)**	-0.85 (1.12)
4	79.56 (0.76)***	-0.42 (0.14)**	-1.53 (0.66)*	-0.52 (0.24)*	-1.17 (0.43)**	-0.79 (1.12)
5	74.12 (1.51)***	-0.41 (0.14)**	-1.53 (0.66)*	-0.50 (0.24)*	-1.14 (0.43)**	-0.79 (1.12)
6	76.27 (1.21)***	-0.44 (0.14)**	-1.42 (0.64)*	-0.38 (0.23)	-0.97 (0.42)*	-0.85 (1.08)

ref: reference category. Presented are regression coefficients with standard errors in parenthesis.
Full-term: 39 - 41 weeks Post-term: 42+ weeks. Early-term: 37-38 weeks. PTB: preterm birth, 37 weeks. MPTB: moderately PTB, 34 - 36 weeks. VPTB: very PTB, 28-33 weeks. EPTB: extremely PTB, <28 weeks.
All models include a random intercept for cohort years and neighborhood, and a cohort year time period indicator in the regression model.
Model 0: adds gestational age categories
Model 1: adds birth weight to model 0
Model 2: includes model 1 plus neighborhood characteristics: 2000 MHI, 2012 HFAI, and 2010 FHH
Model 3: includes model 1 plus student characteristics: type of prior care, student's race, gender, age, disability status, free and reduced meal plan (FARMS) status, number of siblings at birth, multiple birth, neonatal assisted ventilation, fetal distress, and low Apgar scores.
Model 4: includes model 3 plus parent characteristics: maternal and paternal race, maternal age, maternal years of education, marital status, maternal tobacco use, and missing paternal information.
Model 5: includes significant variables from model 4 plus neighborhood characteristics.
Model 6: adds a random intercept for school to model 5.
*$p < 0.05$ **$p < 0.01$ ***$p < 0.001$

Neighborhood characteristics may not have played an influential role in the relation between student birth characteristics and school readiness, but they were independently associated with mean readiness scores (**Table 9.3**). Neighborhood income was modeled separately in model 0, adjusted for neighborhood clusters and student cohort years. Each $10,000 increase in neighborhood MHI in 2000 was associated with a 0.92 point increase in mean composite readiness scores ($p<0.001$). Higher neighborhood MHI in 2010 was associated with a 0.50 point increase in mean readiness scores ($p<0.001$). Greater healthy food availability was associated with a 0.19 point increase in readiness scores ($p<0.001$). A greater percentage of FHHs was associated with a 0.03 point decrease in mean readiness scores ($p<0.01$).

When each indicator was included in model 1c, the results showed each $10,000 increase in the neighborhood MHI in 2000 was associated with a 1.34 point increase in mean readiness scores, adjusted for other neighborhood characteristics. Higher 2010 MHI was associated with slightly lower adjusted mean readiness scores in model 1c, but this relation was not statistically significant. Further analysis showed that mean readiness scores of students born in neighborhoods with a MHI lower than the city average in 2000, but above average in 2010, had lower mean readiness scores than students born in neighborhoods with above average MHI in 2000 and 2010. Independent of MHI levels and the percentage of FHH, greater healthy food availability was associated with a 0.13 point increase mean readiness scores ($p<0.01$). A greater percentage of FHHs was associated with a 0.03 point increase in mean readiness scores ($p<0.05$), adjusted for other neighborhood characteristics, which was a reversal of the unadjusted relation.

The effect of neighborhood characteristics on mean readiness scores changed slightly when adjusted for student birth weight and gestational age in model 2. Neighborhood income effects were attenuated by 54% when all student and parent characteristics were included in model 5, but no substantial change in the HFAI and FHH coefficients was observed. Each $10,000 increase in the 2000 MHI of student birth neighborhoods was associated with a 0.58 point increase in mean readiness scores ($p<0.01$), adjusted for other neighborhood factors, student and parent characteristics. Each unit increase in the availability of healthy food in students' birth neighborhoods was associated with a 0.13 point increase in mean readiness scores, adjusted for other neighborhood, student and parent covariates ($p<0.001$). Similarly, each percentage-point increase in FHHs was associated with a 0.04 point increase mean readiness scores, adjusted for all other covariates ($p<0.01$). Neighborhood effects were reduced by about 50% in model 6 when student school clusters were controlled for with a random intercept.

No statistically significant interactions between any of the main independent variables and neighborhood characteristics were observed.

Table 9.3 Multivariate estimated differences in mean composite school readiness scores and standard errors of Baltimore City born kindergartners by neighborhood impact model progressions, 2002 to 2012, by neighborhood characteristics

		Neighborhood Characteristics			
Model Iteration	Intercept	MHI, 2000	MHI, 2010	HFAI, 2012	FHH, 2010
	β (SE)	β (SE)	β (SE)	β (SE)	β (SE)
0		0.92 (0.15)***	0.50 (0.11)***	0.19 (0.05)***	-0.03 (0.01)**
1c	68.75 (1.88)***	1.34 (0.33)***	-0.09 (0.29)	0.13 (0.05)**	0.03 (0.02)*
2	68.74 (1.64)***	1.27 (0.22)***		0.13 (0.04)**	0.04 (0.01)**
5	74.12 (1.51)***	0.58 (0.20)**		0.13 (0.04)***	0.04 (0.01)**
6	76.27 (1.21)***	0.31 (0.13)*		0.07 (0.03)**	0.02 (0.01)*

ref: reference category. Presented are regression coefficients with standard errors in parenthesis.
MHI: median household income. HFAI: healthy food availability index. FHH: female headed households
All models include a random intercept for cohort years and neighborhood, and a cohort year time period indicator in the regression model.
Model 0: models each variable separately
Model 1: includes all variables shown
Model 2: includes model 1 plus main independent variables: PTB and LBW categories.
Model 5: includes model 2 plus student characteristics: type of prior care, student's race, gender, age, disability status, free and reduced meal plan (FARMS) status, number of siblings at birth, multiple birth, neonatal assisted ventilation, fetal distress, and low Apgar scores; and parent characteristics: maternal and paternal race, maternal age, maternal years of education, marital status, maternal tobacco use, and missing paternal information.
Model 6: adds a random intercept for school to model 5.
*p < 0.05 **p < 0.01 ***p < 0.001

Model diagnostics

Neighborhood model diagnostics showed how well the fitted models explained the variation in school readiness (**Table 9.4**). Model 0's with only birth weight or gestational age categories explained 0.5% of the variation of school readiness scores. Model 0's with individual neighborhood variables showed that the 2000 MHI income explained the greatest amount of variation (0.5%) in readiness scores of the characteristics explored. The 2010 MHI explained 0.3% of readiness score variation, followed by HFAI (0.2%), and FHHs (0.1%).

Similar to results for Aims 1 & 2 with both birth weight and gestational age categories, 0.6% of readiness score variation was explained in model 1. Model 1c that included all neighborhood indicators explained 0.6% of the variation in composite school readiness scores. Student birth weight, gestational age, and neighborhood indicators combined to explain 1.1% of the variation in readiness scores in model 2. Model 3, that included student birth characteristics and other student variables, explained 11.0% of the variation in scores. Adding parent characteristics to the model explained an additional 1.2% of the variation in readiness scores in model 4, and the inclusion of neighborhood level covariates in model 5 explained a total of 12.3% of school readiness score variation.

For each model, the variance explained by the neighborhood random intercept was smaller ($p<0.001$) than the variance explained by the cohort year random intercept ($p<0.05$). In model 6, however, with school included as a random intercept, the neighborhood intercept was not significant, which suggested that student readiness scores within schools were more similar than they were within birth neighborhoods.

Aim 3 Summary

Findings for Aim 3 show that although neighborhood indicators of median household income, healthy food availability, and the percentage of female headed households were independently associated with mean school readiness scores and student birth characteristics, they did not influence the relation between birth characteristics and school readiness. Students born in higher income neighborhoods had higher mean readiness scores, adjusted for other student and parent covariates. Greater healthy food availability at the neighborhood level was independently associated with higher adjusted mean readiness scores as well. And interestingly, a greater percentage of female headed households was associated with higher adjusted mean readiness scores.

Table 9.4 Regression model fit statistics from neighborhood multivariate regression models estimating the differences in mean composite school readiness scores of Baltimore City born kindergartners, 2002 to 2012

Model iteration	Readiness score variance explained, %	AIC	Variance explained by neighborhood random intercept, %	Variance explained by cohort year random intercept, %	Variance explained by school random intercept, %
Model 0: BW only	0.5	311925.9	1.11***	3.24*	
Model 0: GA only	0.5	311914.7	1.11***	3.23*	
Model 0: 2000 MHI only	0.5	312096.8	0.60***	3.22*	
Model 0: 2010 MHI only	0.3	312108.9	0.77***	3.22*	
Model 0: HFAI only	0.2	312117.0	0.91***	3.21*	
Model 0: FHH only	0.1	312125.0	0.99***	3.22*	
Model 1: BW + GA	0.6	311883.4	1.11***	3.24*	
Model 1c: Neighborhood variables	0.6	312095.3	0.49***	3.22*	
Model 2: BW + GA + Neighborhood variables	1.2	311853.6	0.49***	3.24*	
Model 3: BW + GA + Student variables	11.0	307826.8	0.80***	2.66*	
Model 4: BW + GA + Student + Parent variables	12.2	307392.0	0.57***	2.53*	
Model 5: BW + GA + Student + Parent + Neighborhood	12.3	307386.9	0.41***	2.53*	
Model 6: BW + GA + Student + Parent + Neighborhood + School random intercept	11.9	305279.2	0.04	2.76*	8.57***

BW: birth weight categories. GA: gestational age categories. AIC: Akaike Information Criterion. MHI: median household income. HFAI: healthy food availability index. FHH: female headed households.
Student variables: student's race, gender, age, disability status, free and reduced meal plan (FARMS) status, number of siblings at birth, multiple births, neonatal assisted ventilation, fetal distress, and low Apgar scores.
Parent variables: maternal and paternal race, maternal age, maternal years of education, marital status, missing paternal information, and maternal tobacco use.
Neighborhood variables: 2000 MHI, 2012 HFAI, and 2010 FHH.
*$p < 0.05$ **$p < 0.01$ ***$p < 0.001$

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CHAPTER FIVE

DISCUSSION

Overview

The primary goal of this dissertation was to provide insight into the reasons why students in inner-city public school districts are not entering kindergarten ready to learn at similar rates to students from suburban and rural public school districts. The main objective was to determine how birth characteristics influence school readiness in a population-based sample of Baltimore City kindergarten students. A retrospective cohort analysis was conducted of kindergarten school readiness data from Baltimore City Public Schools (BCPS) linked to students' birth certificates. To achieve this objective, three specific aims were explored:

> **Aim 1**: Determine whether LBW (<2500 grams) and PTB (<37 weeks gestation) are related to school readiness among Baltimore City kindergartners, adjusting for maternal and child characteristics at birth.
>
> **Aim 2:** To assess whether type of prior care moderates the relation between LBW and PTB and school readiness, after adjusting for other student and maternal characteristics.
>
> **Aim 3:** To examine whether Baltimore neighborhood characteristics modify the relation between LBW and PTB and school readiness, adjusting for maternal and child characteristics at birth and prior care characteristics at school entry.

This chapter discusses the main findings for each specific aim as well as the strengths and limitations of the study. The chapter concludes with a discussion of the implications for early childhood education and care programs, school districts, parents, and suggestions for future research.

Aim 1: Are low birth weight and preterm birth related to school readiness among Baltimore City kindergartners?

Similar to other studies of the effects of LBW (<2500 grams or 5.5 pounds) and PTB (<37 weeks gestation) on early childhood development and school readiness (Hillemeier, 2011; Isaacs, 2011; Arpino, 2010; Aarnoudse-Moens, 2009), the current findings show that LBW and PTB are significantly associated with lower school readiness after adjusting for other student, parent, and prior care characteristics. Specifically, results showed that adjusted mean readiness scores of students born moderately LBW (MLBW; 1500 – 2499 grams or 3.3 - 5.5 pounds), very LBW (VLBW; 1000 – 1499 grams or 2.2 – 3.3 pounds), and extremely LBW (ELBW; <1000 grams or <2.2 pounds) were 0.98, 1.30, and 4.44 points lower than for students born normal birth weight (NBW; $\geq$ 2500 grams or $\geq$ 5.5 pounds), respectively. Further, the adjusted readiness scores of students born ELBW were significantly lower than the readiness scores of students born VLBW and MLBW. No difference in readiness scores was observed between students born MLBW and VLBW.

Readiness scores also varied significantly by gestational age, but to a lesser extent. Students born post-term (42+ weeks) had the lowest adjusted mean readiness scores (-1.42 points) compared to students born full-term (39-41 weeks gestation), followed by students born very PTB (VPTB; 28-33 weeks gestation; -0.98 points) and students born early-term (37-38 weeks gestation; - 0.44 points). No significant difference in adjusted mean readiness scores was observed for students born moderately PTB (MPTB; 34-36 weeks gestation) and extremely PTB (EPTB; <28 weeks gestation) compared to full-term students. Further, no significant difference in the estimated mean readiness scores among each non-full-term gestational age category was observed.

These findings suggest that students born LBW should not be treated as a uniform group when exploring early childhood development outcomes because lower readiness scores were observed for ELBW students compared to MLBW, VLBW, and NBW categories. They also suggest significantly different developmental trajectories may be present for students born early-term or post-term relative to those born full-term, which has not typically been explored in prior studies.

The results further show that together, student and parent characteristics, and prior care setting explain about twelve percent of the variation in composite school readiness scores in this predominantly low-income, African American, urban sample of kindergarten students in a public school district. The same model explained 12.4% of the variation in language & literacy domain standardized readiness scores, which was about two percentage points greater than the amount of variation explained in a recent study of Maryland school readiness data. Forry et al (2013) explored the impact of child care settings on school readiness in the language & literacy domain using 2009 and 2010 state cohorts of similar Maryland Model for School Readiness (MMSR) data but their models did not account for characteristics from student birth certificates. Most of the variation in composite school readiness scores in the current study is explained by student characteristics (5.9%) followed by the type of prior care setting (4.6%), and finally parent characteristics reported on the birth certificate (1.7%); LBW and PTB categories combined explained only 0.6% of the variation in readiness scores.

In general, adjusted mean readiness scores for students not born NBW or full-term did not vary significantly by the different domains of school readiness. Of note, however, was the observation that students born EPTB, who did not have significantly lower adjusted composite mean readiness scores, had physical development and health domain readiness scores that were significantly lower than those of students born at other gestational ages. This finding suggests that students born LBW and PTB have lower readiness scores in the overall domain of readiness, but also that kindergarten teachers noticed significant physical differences in EPTB students related to their gross and fine motor development, a finding congruent with results of prior studies (Aarnoudse-Moens, 2009).

Studies of the developmental outcomes of PTB and LBW children have rarely examined composite school readiness as a continuous measure. These studies often focus on one or two different cognitive or behavioral scales to assess child development (Keller-Margulis, 2011), making it difficult to compare the current findings with those previously reported in the literature.

Isaac et al (2011) observed that LBW students in the nationally representative Early Childhood Longitudinal Study, Birth Cohort (ECLS-B) had standardized adjusted reading and math scores that were one-tenth and one-fifth of a SD lower than NBW students, as well as a lower probability of school readiness. In a meta-analysis of the neurobehavioral outcomes of VPTB and VLBW children, Aarnoudse-Moens et al (2009) showed that the combined effects suggest that VPTB ($\leq$33 weeks) and VLBW ($\leq$1500 grams) “children score 0.60 SD lower on mathematics tests, 0.48 SD [lower] on reading tests, and 0.76 SD [lower] on spelling tests than term-born peers”. Hillemeier et al (2011) observed that VLBW ($\leq$ 1500 grams) children had significantly higher odds of low cognitive scores at 24 months. VLBW children with cognitive delays at 24 months also had more than three times the odds of having low cognitive scores at 48 months. It is unclear whether the reference group in their study included MLBW children. Chen et al (2014) found that in a national population level survey of Australian kindergarten students, LBW, PTB, and small for gestational age students "were more likely to have significantly lower performance on cognitive skills underlying school readiness".

The findings presented in the current study show that LBW and PTB status at birth influences school readiness in a predominantly low-income urban setting; but the readiness gap for LBW children is greater than it is for PTB children. Grouping all LBW categories, particularly VLBW with ELBW, together may overlook an important vulnerable population of children in need of more focused attention in the early childhood years to better prepare ELBW children for school in kindergarten.

It is likely that student disability played an important role in these findings as well. The readiness gap was greatest between students with and without a disability. Students born LBW were far more likely to have some form of disability at school entry than those born NBW. LBW students had 58% greater odds of having some form of disability at school entry and students born ELBW had five-fold greater odds of having some form of disability at school entry as compared to NBW students.

Aim 2: Does the type of prior care received before entering kindergarten influence the relation between birth characteristics and school readiness?

As documented in prior studies on the impact of prior care on early childhood outcomes and school readiness, the type and quality of prior care is indeed an important determinant for healthy child development (Keys, 2013; Lee, 2014; Forry, 2013; Fram, 2012; Abner, 2013). The current study provided further evidence to support this finding. Readiness scores varied significantly by the type of care kindergarten students received in the twelve months prior to entering school after adjusting for other student and parent characteristics. Most importantly, results showed that prekindergarten care plays a significant role in improving the academic readiness of LBW and PTB children at school entry compared to other types of prior care.

Initial unadjusted results indicated that students who attended a private nursery prekindergarten (PK) program had the highest mean composite readiness scores. Taking into account other student and parent characteristics, however, revealed that students who attended a district PK program prior to school entry had mean readiness scores that were higher than the readiness scores of students who attended any other prior care setting. Students who attended a Head Start program had readiness scores that were significantly lower than those of PK students, but higher than students who attended a child care center and those who received family or informal home care. Students who received informal home care or family child care prior to school entry had the lowest adjusted readiness scores. These students scored, on average, more than six points lower than similar students who attended a school district funded PK program. Further, students who received informal home care or family child care had a nearly three-fold increased adjusted odds of not being ready at school entry compared to similar students who attended a district PK program.

The finding that school readiness scores vary significantly by type of prior care is not a novel observation. Indeed, Forry et al (2013) used similar statewide Maryland

Model for School Readiness (MMSR) data to show that students enrolled in PK and other center based care, except Head Start, had a significantly greater probability of being scored “fully ready for school” in the Language & Literacy and Mathematical Thinking domains compared to children who received home-based care. This finding also is not isolated to Maryland, as Coley et al (2013) observed that in the United States (US) and in Australia attending “formal center-based early education and care programs [was] more promotive of children’s cognitive skills than were informal early education and care settings such as relative, nanny and other home arrangements”. Similar to our findings, Lee et al (2014) observed that Head Start participants had reading and math scores higher than those of students who received no formal care, but lower than those of children who attended a PK program, and similar to students who attended other types of center based care. Other studies group PK together with other center based care (Isaacs, 2011; Abner, 2013; Fram, 2012). The results presented here show that this practice may obscure differences by setting and type of care, particularly in low-income urban study populations.

The current study adds to the extant literature in showing that district PK enrollment best prepared students for school, but the beneficial effects were not equitably distributed among all students; students born ELBW who attended a district PK program had significantly lower readiness scores than NBW students who attended these programs. A recent study was conducted by Chen et al. (2014) on the impact of childcare on school readiness for students born premature in a nationally representative survey of children in Australia. The authors found that the influence of preschool enrollment on the relation between prematurity and school readiness was only significant for small for gestational age students with lower educated mothers.

To the authors' knowledge, our findings are the first to document a significant differential impact of the type of childcare received prior to kindergarten entry on the relation between LBW and school readiness in a low-income urban population-based sample in United States (US). Specifically, only ELBW students who attended a district PK program had readiness scores significantly higher than the scores of ELBW students who received no formal care; no other childcare setting provided a significant increase in school readiness scores for students born ELBW. MLBW and VLBW students who attended a child care center had readiness scores that were no different than students of similar birth weight who received no formal care. Further, MLBW and VLBW students who attended a district PK program had readiness scores that were significantly higher than the scores of similar birth weight students who attended a private nursery or other PK program. In each birth weight group, readiness scores did not differ significantly for students who received care at non-district PK programs, Head Start programs, or child care centers. Additionally, students who received care at a child care center had adjusted mean readiness scores that did not differ significantly from similar students who received no formal care.

The observed differences in readiness scores by prior care type for students born LBW may be due to a number of factors. Readiness scores of kindergarten students in BCPS were highest for students who attended a BCPS funded PK program. This relation was not unexpected given the possibility that PK students may have had some exposure to their future kindergarten teachers, and this exposure may introduce bias into the teachers' readiness rating of the student. For this bias to occur consistently over the ten year study period, however, is unlikely and does not fully explain the observed benefit of attending a district funded PK program above and beyond other prior care settings. A more likely reason is that Maryland school districts are consistently highly ranked nationally in terms of their public investment in and access to quality PK programs (Barnett, 2013). Further, as Forry et al (2013) documented, the majority (56.2%) of Maryland PK students in 2009 and 2010 were also enrolled in some form of subsidized child care which may explain the added benefit observed for PK care in the current study.

In summary, prekindergarten programs, and specifically school district funded PK programs, appear to have best prepared children for school regardless of student and parent characteristics. Attendance at a Head Start or other PK program was less effective, although more effective than no formal care. Most importantly, district PK enrollment significantly improved the readiness scores of students born ELBW, while district PK, private nursery and other PK programs significantly improved the readiness of students born MLBW or VLBW. These findings are particularly important for preparing students for school in Baltimore and other urban school districts. Currently, about twenty percent of kindergarten students still received no formal child care in the year prior to entering school (BCPS, 2014); based on the current study sample, the rate is slightly higher for students born LBW and FARMS students. In order to begin to close the gap in school readiness, particularly in low-income school districts, increasing enrollment in PK and other types of formal care must be prioritized.

Aim 3: Are Baltimore neighborhood characteristics associated with the relation between LBW and PTB and school readiness, adjusting for parent and child characteristics at birth and the type of prior care received prior to school entry?

Data was obtained from the Baltimore Neighborhood Indicators Alliance (BNIA) to examine the impact of residential neighborhoods at the time of birth on kindergarten school readiness scores. After considering several indicators to characterize Baltimore City neighborhoods, four were chosen related to socio-economic status (SES). These indicators included: the 2010 percentage of female headed households (FHH), the 2000 and 2010 median household income (MHI), and the 2012 healthy food availability index (HFAI). Selection of SES indicators to differentiate neighborhoods, rather than indicators of crime and safety, housing and community development or another construct, is congruent with prior studies of neighborhood influences on school readiness or early childhood outcomes (Carpiano, 2009; Malacova, 2009; Andreias, 2009; Caughy, 2008; Kohen, 2002; Oliver, 2007).

Initial analyses showed that each indicator was significantly correlated with mean school readiness scores and that FHH and HFAI varied significantly by neighborhood income levels. Children from higher income neighborhoods had higher mean readiness scores, greater healthy food availability, and lower percentages of FHHs - and vice versa. Further, mean neighborhood birth weights were heavier and gestational ages were longer in neighborhoods with higher MHI, greater healthy food availability, and lower percentages of FHHs. Although average MHI levels increased from 2000 to 2010, the majority of neighborhoods' relative MHI position (percentile rank) declined or remained unchanged.

Findings from multivariate hierarchical linear models showed no evidence of an effect of neighborhood characteristics on the relation between LBW or PTB and composite school readiness scores. Consistent with previous research, however, was the finding that neighborhood level predictors were independently associated with student readiness scores (Carpiano, 2009; Oliver, 2007). Regression models showed that the 2000 MHI explained the most variation in student level readiness scores of the neighborhood predictors considered. Each $10,000 increase in MHI was associated with a 0.31 point increase in mean readiness scores. HFAI and FHH were also both positively associated with readiness scores, independent of student and parent characteristics.

A higher percentage of FHHs at the neighborhood level was associated with higher mean readiness scores; this finding is somewhat counter to previous research. Kohen et al (2002) observed that the percentage of single female-headed families in Canadian neighborhoods was positively associated with behavior problems in four and five year old children, but no relation with verbal ability was observed. The different association with school readiness may be due to differences in the study populations. The percentage of single female-headed families in Kohen's study ranged from seven percent in low poverty neighborhoods to 15.4% in high poverty neighborhoods. The majority (53%) of households in the current study were female headed households. This finding may suggest that in Baltimore, a female headed household may be a more positive influence on child development than the alternative, whichever it may be.

The finding that healthy food availability is a significant predictor of school readiness suggests that greater availability of healthy food at the neighborhood level, in this low-income urban setting, is associated with higher school readiness scores independent of other student and parent level factors considered. The mechanisms at work with this indicator are unclear. Prior research of HFAI scores in the Baltimore area found that higher scores were associated with fewer minority residents and greater neighborhood income. We adjusted for neighborhood income in the current study and still found a positive relation between HFAI and readiness scores. Further investigation revealed that among students born in low and medium SES neighborhoods no direct relation between HFAI and school readiness was observed, even for students born in neighborhoods with above average access to healthy foods. In higher SES neighborhoods, however, readiness scores in neighborhoods with above average HFAI values were significantly higher than readiness scores in neighborhoods with below average HFAI values. Further research should examine whether increasing the availability of healthy foods in lower SES Baltimore neighborhoods may confer similar increases in kindergarten readiness or other early childhood health and education outcomes.

Other findings

In addition to the aforementioned findings, this unique data elicited several other observations worth noting.

The intergenerational impact of education cannot be overstated as years of maternal education was one of the strongest and most consistent parent level predictor of children's school readiness. Years of maternal education alone explained nearly 2% of the variation in student readiness scores. This relation has been consistently documented in prior studies that examined different aspects of school readiness in kindergarten students (Hillemeier, 2011; Isaacs, 2011; Breslau, 2001; Bohm, 2002). Our results showed that students of mothers with less than twelve years of education, a proxy for no high school diploma or GED, had readiness scores more than three points lower than those of similar students with mothers who had thirteen or more years of education, a measure of at least some post high school education. Kindergarten students of mothers with less than twelve years of education also had nearly two times the odds of not being ready at school entry compared to students of mothers with thirteen or more years of education.

The education effect was not attenuated by income levels; among students with similar family incomes, as determined by FARMS status, those whose mothers had fewer years of education (≤12 years) still had significantly lower readiness scores, adjusted for other parent and student characteristics.

Results further showed that maternal tobacco use was significantly related to school readiness scores, independent of maternal education levels. This finding replicated similar effects of maternal tobacco use and smoking on early childhood outcomes in other recent studies. Moore et al (2014) observed that readiness scores of Australian kindergarten students were significantly lower for students whose mothers smoked during pregnancy. Isaacs et al (2011) found a significantly lower likelihood of students being school ready whose mothers reported smoking in the last three months of pregnancy in the nationally representative ECLS-B cohort as well. Maternal smoking may serve as a marker for other risk factors like poor nutrition, greater psychosocial stress, and substance abuse that are associated with adverse birth outcomes and poor child development (Erickson, 2012; Schneider, 2008).

Lack of paternal involvement in the child's life at birth, as assessed by missing paternal information on the students' birth certificate, was associated with lower adjusted composite readiness scores. This finding supports previous research into the fathers' role in fostering healthy child development, particularly in urban settings (Black, 1999). Using birth certificate data in this way to examine paternal involvement was found to be associated with fetal and infant morbidity (Alio, 2010), but the effect on school readiness is the first to the authors' knowledge.

Kindergarten students with a low one or five minute Apgar score (< 7) also had lower unadjusted composite school readiness in this study sample. Only students with low one-minute Apgar scores had significantly lower adjusted readiness scores, but non-significant findings for low five-minute Apgar scores may be due to the low prevalence in the study sample (1.5%). This finding was similar to the results observed by Moore et al. (2014) who documented a significant positive relation between Apgar scores (unclear whether 1 or 5 minute) and numeracy attainment in Australian kindergarten students. Beaino et al (2011) observed that low one-minute Apgar scores were associated with a 50% greater unadjusted odds of severe cognitive deficiency at age 5 in a large cohort of very PTB (<32 weeks) children using the large French EPIPAGE cohort study, but no significant difference was observed when adjusting for other characteristics. Our findings suggest that at least in a low-income urban population, poor one-minute Apgar scores may serve as a very early warning sign of significant developmental delays.

The results also showed that students who experienced fetal distress during delivery had lower readiness scores than those who did not, adjusted for all other student and parent characteristics. In prior studies, similar risk factors are grouped together with other conditions recorded on the birth certificate associated with labor and delivery complications. For example, data from the ECLS-B cohort revealed no relation between labor complications and the odds of children having lower cognitive scores at 48 months (Hillemeier, 2011) or having mathematics difficulty at 60 months (Morgan, 2014). The current findings, again, point toward another potential early warning sign for developmental delays for low-income urban minority children.

Finally, unadjusted comparisons showed lower readiness scores for students who received assisted ventilation as a neonate, but the adjusted results showed that these students had significantly higher mean readiness scores than similar students who did not receive assisted ventilation as a neonate. This finding may suggest the presence of an unmeasured confounder in the study sample – respiratory distress syndrome (RDS) among premature infants (Patrianakos-Hoobler 2009 & 2011). In our study, students who received neonatal assisted ventilation had more than eight times the odds of being LBW or PTB than students who did not receive assisted ventilation. Students who received this treatment had higher adjusted readiness scores than those who did not, which may point to an unmet medical need among low-income minority neonates in this urban population and warrants further investigation to better understand the mechanisms at work.

Strengths and Limitations

The study limitations and strengths are discussed in the following.

Strengths

A major strength of the current study was the use of municipal databases to create a unique retrospective cohort study to better understand an important public health and educational outcome – school readiness. The study and data represented the linkage of approximately 70% of kindergarten students from the fall of 2002 to 2012 in a large predominantly low-income urban public school district. The linked data was used to better understand ways to determine how birth characteristics and prior care influence school readiness in kindergarten students, with the ultimate goal of helping to inform early childhood public health and education policy. Findings from this study can be generalized to other large urban public school districts of the US and possibly abroad.

Prior studies that examined the relation of student birth characteristics on school readiness have been carried out with smaller sample sizes (Keller-Margulis, 2011) or included nationally representative samples (Hillemeier, 2011; Isaacs, 2011) in which school readiness was typically measured as a yes or no construct rather than as a continuum (Snow, 2006). Studies often showed that readiness scores were lowest for minority and low-income students, but the next step of understanding the specific reasons why was often not undertaken. Our study sought to fill this knowledge gap and extend the understanding of the mechanisms that contribute to school readiness by measuring readiness as a continuous outcome and using a predominantly low-income minority study population.

Finally, the large population based sample provided sufficient statistical power to adjust for multiple risk factors that may influence readiness scores. A number of risk factors also were available from the combined data. Additionally, the large sample made it possible to examine the effects of neighborhood risk factors on school readiness through multivariate multi-level regression models. Some critiques of prior neighborhood level studies include limited sample size and a lack of attention on early childhood outcomes (Sampson, 2002).

Limitations

Data for this study was derived from a record linkage of Baltimore City Public Schools (BCPS) kindergartners to their birth certificates at the Maryland Department of Health & Mental Hygiene (MDHMH) Vital Statistics department. The final study sample did not completely represent the original cohort proposed for study in a few different ways. There were fewer Hispanic and non-FARMS students and students in informal home care settings in the study sample than the original cohort. The demographic make-up of BCPS' enrollment population is predominantly African American and FARMS which means that although the population from which the study sample was drawn is somewhat homogenous, the missed linkages indicate that our study sample may in fact be more homogenous than the original cohort. Additionally, in the linking process, variables related to maternal hypertension from the birth certificate were omitted unintentionally. These limitations may in the end be minor, but were worth noting. The use of a sample of kindergarten students from a public school district for the study population also limits the ability to generalize the results to private school kindergarten students in Baltimore City.

There are several characteristics of the data that may be seen as a limitation as well. A main objective of the current study was to identify the moderating effects of prior care setting on the relation between birth characteristics, mainly LBW and PTB, and school readiness as determined by the Maryland Model for School Readiness (MMSR). Using these data alone to discern the effects of prior care settings is limited by parents' self-reports about their child's type of prior care when students are enrolled into BCPS. The lack of a verifiable indicator resulted in the need of staff at BCPS' Office of Achievement and Accountability (OAA) to confirm student enrollment in the districts' prekindergarten (PK) program. Similar to the efforts of Forry et al. (2013), OAA staff validated any parent reports of PK enrollment with actual student attendance records ('District PK') and created a category of 'Other PK' where students were not identified but reported to have attended a PK program. To that end, the effort was made to reduce self-reporting bias by the district efforts, but the levels of prior care studied could not be verified by the principal investigator (PI) for other settings.

Further, due to parent reporting of kindergartners' prior care setting, the current study could not control for the quality, duration or level of engagement in the prior care received in formal and informal settings. It is entirely possible for students who received informal home care to have been educated and cared for by well trained staff in an undocumented setting and for students who attended a formal child care center to have had infrequent attendance, limiting the benefits of this type of care; the data could not account for these limitations. The recent evidence is mixed, however, of the impact of quality of early childhood care on developmental outcomes, so the impact of this limitation on the current findings may be small (Abner, 2013; Keys, 2013).

Another data limitation was use of kindergartners' birth certificates across multiple years. Inclusion of the same student in different cohorts was ruled out by BCPS OAA staff who limited the dataset to only unique first time kindergartners in each cohort year. We could not account for double counting of student's mothers; that is, different students of the same mother were included in the cohort for different school years. Kindergartners in the final study sample may have the same mother, particularly because the sample was restricted to only students who were born with a Baltimore City census tract listed as the mother's residential location. This redundancy was not accounted for by

BCPS staff nor in the process of linking records and is therefore not controlled for in the estimation of maternal effects on the school readiness outcomes presented.

Another limitation was the way in which neighborhood level data was examined. The ideal method of evaluating the impact of neighborhood level effects on the association between birth characteristics and school readiness five years later would be to follow a group of students over time in a given area, or city, and examine the type and duration of residence in neighborhoods in which the student lived between birth and school entry. The structure and availability of our data did not permit this analysis at the population level. Given data constraints, the focus of the neighborhood analysis was on characteristics of the students' birth neighborhood during the specified time period. The possibility that students did not reside in the same Baltimore Neighborhood Indicators Alliance (BNIA) neighborhood identified at birth as they did at school entry is likely high, but the magnitude is unknown. Estimates of school mobility in Baltimore City would not be appropriate in this situation because multiple schools are located within each of the 55 neighborhoods and would over-estimate the actual student mobility between neighborhoods.

Finally, due to constraints in the data used in the current study, we could not control for specific parenting behaviors and parent-child interactions which are critical components of child development, particularly in low-income settings, and also are related to school readiness (Hill, 2001; Connell, 2002). A study by Connell et al (2002) found that parent-child interactions characterized by warmth, structure and responsiveness were positively associated with communication skills, receptive communication, and teacher ratings of the child's social skills in 47 FARMS students in a southeastern US city. Parent-child interactions explained approximately 7, 17, and 8 percent of the variation in child readiness scores related to communication skills, receptive communication, and social skills, respectively. Hill (2001) observed that "maternal warmth or acceptance was positively related to prereading and premath performance" in 103 kindergarten children from a semi-urban southeastern US city, and that this relation played a larger role among low-income families.

These prior studies suggest that not controlling for parenting behaviors and/or parent child-interactions when estimating the relation between birth characteristics and school readiness as well as the effect of prior childcare on this relation may bias the results away from the null. Much of the estimated effect of prior care may well have been accounted for had measures for parenting behaviors and parent-child interactions been included in the models. Additionally, data constraints did not allow for the adjustment of other early childhood risk factors associated with school readiness such as child maltreatment, out-of-home placement, and homelessness in early childhood (Fantuzzo, 2007). The unmeasured effects of the latter two risk factors are particularly salient in a city like Baltimore where Baltimore Outreach Services estimates that on any given night 4,000 people are homeless and the fastest growing homeless demographic in the city is women and children[10].

Implications

Children born with adverse birth outcomes like low birth weight (LBW) and preterm birth (PTB) are more likely to have significant developmental delays in early childhood (Aarnoudse-Moens, 2009; Arpino, 2010) and at school entry (Isaacs, 2011)

[10] Baltimore Outreach Services: http://www.baltimoreoutreach.org/

than children born at a normal weight and full-term. An important determinant of school readiness is the type of care the child receives before entering school (Keys, 2013; Forry, 2013; Fram, 2012; Abner, 2013), particularly for students from low-income families (Lee, 2014). Further, several studies have shown that school readiness is lower in low socio-economic status (SES) neighborhoods (Andreias, 2009; Caughy, 2008; Oliver, 2007). Few studies, however, have examined whether a particular type of prior care best prepares LBW or PTB students for school than others (Chen, 2014), and whether neighborhood level indicators significantly influence this relation. Understanding the determinants of school readiness in a low-income urban setting is important to helping close the income gap in school readiness, which can in turn help close the income gap in later academic outcomes and ultimately adult health outcomes.

The current findings show that in a large urban school district, students born LBW or PTB had significantly lower readiness scores than their NBW or full-term peers. The results also showed that district funded PK attendance best prepared students for school. This finding was particularly salient for ELBW students who, on average, had mean readiness scores that were lower than the recommended cutoff for determining school readiness. ELBW students who attended a district funded PK, however, had mean readiness scores that were above the cutoff and significantly higher than ELBW students who received no formal care. For students who were born MLBW or VLBW, those who attended a district funded PK program had readiness scores that were significantly higher than MLBW or VLBW students who attended a private nursery program or some other PK program.

These findings provide evidence for the need to continue to expand available PK seats and attendance of district funded PK programs in Baltimore and potentially other urban public school districts. Currently, about a quarter of BCPS kindergarten students receive no formal care prior to entering school, and rates of informal childcare are higher for FARMS students than non-FARMS students. More research is needed to determine why these students are not receiving some type of formal care and education in early childhood, and where possible, the school district should seek to address those barriers.

Low birth weight did not explain a large amount of the variation in school readiness scores but there was clear evidence showing that the fifteen percent of kindergarten students in BCPS born LBW had lower readiness scores than NBW students. The best way to decrease the LBW-NBW student readiness gap is to first decrease the rate of LBW in Baltimore City, and second, to ensure LBW children receive some form of formal child care – specifically district funded PK care and education prior to entering kindergarten.

An important next step to follow-up on the current findings would be to examine whether similar results would be observed using statewide MMSR data in other Maryland public school districts. Examining the relation between birth characteristics and school readiness among Baltimore City private school kindergarten students would provide an insightful contrast. Baltimore City's readiness scores have consistently been one of the lowest in the state and a comparison of the results using a similar methodology would help to validate the stated conclusions presented here.

Further research should seek to better understand the variation in the quality of care provided by different formal care settings and to understand how effective each setting prepares children for school systematically. As previously mentioned in the study limitations, our study depended on accurate parent reports of their child's care prior to entering school. Understanding whether similar findings would be observed using data that systematically track children who attended different prior care settings would help to eliminate any parent-reporting bias as well as include estimates of participation and attendance rates. Linkage of municipal databases to create integrated data systems in order to research important public health issues at the population level has been gaining in popularity as of late. Linked data systems are useful for better understanding child health outcomes in particular (NRC, 2004). For the current study, such a system would create a better estimate of prior care effect on student readiness scores, in addition to providing insight into other upstream determinants of child health outcomes.

Researchers at the University of Pennsylvania used the Kids Integrated Data System (KIDS) in Philadelphia to study how out-of-home placement was related to school readiness factors, and to examine how child maltreatment and homelessness mediated that relation (Fantuzzo, 2007). KIDS is a collaboration between University of Pennsylvania researchers and several Philadelphia municipal agencies to link databases in order to conduct research that informs practices and policies for children and youth. Participating agencies include the Department of Public Health, the Department of Human Services, the School District, Behavioral Health System, and the Office of Emergency Shelter and Services. Greater detail about the procedures taken to create agreements between City, State, and University agencies, and to comply with Health Insurance Portability and Accountability Act (HIPAA) and Family Educational Rights and Privacy Act (FERPA) guidelines are described elsewhere (Fantuzzo, 2005).

The social, behavioral and economic implications of the current findings cannot be understated. School readiness scores of students with mothers with fewer years of education were significantly lower than the readiness scores of students with mothers who had thirteen or more years of education, even among non-FARMS students, which served as a proxy for upper-income status in the current study, and regardless of the type of prior care received. This finding, consistent with other studies of school readiness (Hillemeier, 2011; Isaacs, 2011), suggests that in addition to the need for increased access to effective quality PK programs, early childhood intervention programs with a parent education component may be most effective (Ramey, 1995). Ultimately, in order to attenuate the maternal education effects on school readiness, parents must be better educated, and this starts with entering school ready and prepared to learn in early childhood to break the ongoing low education cycle.

An important modifiable behavior related to lower readiness scores was maternal tobacco use in the current study. Study data limits resulted in an inability to determine whether the main mechanism behind this risk factor was due to a smoking during pregnancy effect or a long-time smoker effect or whether smoking served as a marker for other risk factors like stress, substance abuse, or poor nutrition. Regardless, this finding provides further evidence that efforts toward increasing preconception and prenatal smoking cessation may be an important component for improving school readiness, and likely child development in general.

Economically, the findings from this study highlight an effective avenue that should be explored to improve young adult health and education in school districts serving primarily low-income students with high truancy and juvenile crime rates. Crime among young adults happens in part because troubled students do not attend school as often as they should and are not as engaged in school. The crimes of disengaged and troubled youth who should be in school cause local governments to react by investing more in policing efforts, juvenile detention centers, and prisons, instead of preventing crime by ensuring youth grow up invested in themselves and their communities.

Investment in effective early childhood development programs that increase the school readiness of students, like PK programs, is an effective and essential method for keeping students in school and helping them achieve academically. This investment in turn helps create a more engaged and productive citizenry. In fact, a leading economist interested in the macro level impacts of micro level early childhood development programs has shown that every "dollar invested in high-quality early childhood education produces a 7 to 10 percent per annum return on investment" (Heckman, 2011). As of 2008, it cost between \$66,000 and \$88,000 to incarcerate a juvenile for 9–12 months, which can still lead to recidivism (Mendal, 2011). The cost to enroll a 4-year old in quality center-based early childhood care is estimated to be from \$4,300 to \$12,350 per year for a family depending on the state (Child Care in America, 2013). In 2013, the estimated amount spent on enrolled three and four year old prekindergarten children by the state of Maryland was \$4,386 (Barnett, 2013). It is important to point out that in our study students who attended child care centers did not have higher readiness scores than students who attended publicly funded district PK programs. Therefore, investing in public PK programs in low-income public school systems may be the most affordable and efficient way to increase school readiness, particularly for students born LBW. Higher rates of informal childcare for students from low-income families further highlight the need for increased awareness about the importance of school readiness and how formal childcare best prepares children for school, particularly in public school districts in large urban cities with a large population of low-income families.

Conclusion

Aligned with prior research, this study showed that student born low birth weight (LBW) or preterm had lower school readiness scores in a large urban school district and that readiness scores varied significantly by the type of prior care students received. Not previously shown in the literature, however, is the finding that readiness scores of students born LBW varied significantly by prior care and that district funded PK enrollment best prepared LBW students for school compared to other prior care settings, even private nursery PK. Neighborhood characteristics of median household income, the percentage of female headed households and the availability of healthy food did not have a significant impact on the relation between students' birth characteristics and school readiness, but each characteristic was independently associated with school readiness, adjusting for student and parent characteristics, although the effect of each was small.

The study results suggest that efforts aimed at improving school readiness in low-income urban settings should be directed at increasing the availability and enrollment of publicly funded PK programs and in turn, increasing maternal and paternal education levels over the long run. Further, evidence shows that readiness scores of students who attend a district funded PK program vary significantly by student birth weight. These results suggest that greater attention should be given to incoming student family and child health backgrounds in order to improve the effectiveness of publicly funded PK programs on school readiness.

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APPENDICES

Appendix A. Description of Maryland Model for School Readiness (MMSR) assessment domains and indicators			
Domain	**Skill**	**Indicators**	**Description**
I. Social and Personal	Self-Concept	Shows initiative and self-direction	Independence in thinking and action enables children to take responsibility for themselves. Most five year olds can make choices among familiar activities, participate in new experiences, and are willing to take some risks.
	Self-Control	Follows classroom rules and routines	Children who are successful within a group know and accept the rules established for that particular group.
		Uses classroom materials purposefully and respectfully	One of the major challenges of school for five year olds is learning how to care for classroom materials. With some reminders, a child learns how to use materials thoughtfully (so the materials continue to be available for others) and how to put things away so that others can easily find them.
	Interaction With Others	Interacts easily with one or more children	Kindergarten children are beginning to play cooperatively with one or more children, listen to peers and understand their feelings, and solve problems cooperatively.
II. Language & Literacy	Listening	Gains meaning by listening	Young children are actively involved in learning about their world by watching and listening. At five years, children can listen for meaning in such different situations as one-on-one conversations with children or adults, small and large group activities, story times, and videos.
		Demonstrates beginning phonemic awareness	With frequent demonstrations by the teacher, children recognize and produce rhyming words, identify beginning and ending sounds, and begin to discriminate the smaller parts of words, first distinguishing syllables and, later, sound within syllables.
	Speaking	Speaks clearly and conveys ideas effectively	During kindergarten, children begin to understand how to express their ideas in group discussions as well as in one-to-one conversations.

	Reading	Shows some understanding of concepts about print	Kindergartners realize that print conveys meaning, spoken language can be written down and read, and certain words are always written the same way.
		Comprehends and responds to fiction and non-fiction text	Kindergartners demonstrate their understanding of what they hear by answering questions about the text, predicting what will happen next using pictures and content for guides, and retelling information from a story in sequence, adding more details and story elements over time.
	Writings	Uses letter-like shapes, symbols, letters, and words to convey meaning	Children begin using drawings to convey ideas, adding letters or words randomly to their written communication.
III. Mathematical Thinking	Math processes	Begins to use and explain strategies to solve mathematical problems	Young children solve problems and explain their reasoning by working with concrete objects, drawing pictures, or acting out solutions.
	Numbers and Operations	Shows understanding of number and quantity	Kindergarten children can count objects to at least 20; many learn to count verbally (that is, by rote) to 100. They can count using one-to-one correspondence reliably, use objects to represent numbers, and use numerals to represent quantities.
	Patterns, Relationships, and Functions	Recognizes duplicates and extends patterns.	Kindergartners can recognize, create, copy, and extend simple patterns using concrete objects, sounds and physical movements.
	Geometry and Spatial Relations	Recognizes and describes some attributes of shapes.	As children play with unit blocks, table blocks, pattern blocks, shape sorters, peg boards, and geoboards, they gain a concrete understanding of shape and form.
IV. Scientific Thinking	Inquiry	Seeks information through observation, exploration, and	As questions are raised, kindergartners seek answers primarily through exploration, manipulation, and careful observation using their senses.

		descriptive investigations.	
		Uses simple tools and equipment to extend the senses and gather data.	Although kindergarteners begin to observe using their five senses, they are very intrigued with tools that extend the power of their senses and that they associate with grown-up activities. Scientific tools include magnifiers, gears and pulleys, calculators and computers, and simple balance scales and rulers.
	Physical Science	Identifies, describes, and compares properties of objects.	With prompts from the teacher, five year olds notice what things are made of and describe numerous attributes of objects including size, shape, color, texture, weight, temperature, whether objects are attracted or unaffected by magnets, and whether various objects sink or float.
	Life Science	Observes and describes characteristics, basic needs, and life cycles of living things.	Kindergartners begin to differentiate living and non-living things by studying plants and animals. They begin to learn about relationships between animals and plants and the environment in which they live.
V. Social Studies	People, Past, and Present	Identifies similarities and differences in people's characteristics, habits, and living patterns.	Kindergartners develop self-identity by comparing themselves with others.
	Human Interdependence	Describes some people's jobs and	Young children are ready to examine their communities and explore the many roles people fill in helping each other live.

		what is required to perform them.	
		Begins to be aware of technology and how it affects life.	Kindergartners are very interested in the technology that is so much a part of the world around them (television, telephones, vehicles, video games, VCRs, microwave ovens, computers).
	Citizenship and Government	Demonstrates awareness of the reasons for rules.	Children's understanding of the reasons for rules and laws comes about as they discuss problems in the classroom and school and participate in making reasonable rules that directly involve them.
VI. The Arts	Expression and Representation	Participates in group music experience	Young children enjoy singing, making up silly and rhyming verses, using instruments, learning finger plays, and using music to tell stories and express feelings.
		Participates in creative movement, dance, and drama	Young children are very active and need opportunities to move and stretch their bodies.
		Uses a variety of art materials to explore and express ideas and emotions	Kindergartners need and enjoy opportunities to explore using a variety of art materials.
	Understanding and Appreciation	Respond to artistic creations or events	Kindergarteners are able to appreciate the artistic creations of others, the skill of a dancer, or someone's ability to play a musical instrument.
VII. Physical Development and Health	Gross Motor Development	Moves with balance and control	Young children are very active, seeming to be in constant motion. Kindergarten children can run smoothly, hop many times on each foot, and climb up and down stairs using alternating feet.
	Fine Motor Development	Uses eye-hand coordination to perform tasks effectively	Kindergartners are continuing to improve their eye-hand coordination and accomplishing tasks with greater precision.

	Personal Health and Safety	Performs self-care tasks competently	Kindergartners are quite competent about taking care of their own physical needs and often volunteer to help classmates who are struggling with buttons and laces.
		Shows beginning understanding of and follows health and safety rules	Kindergartners are interested in health and safety issues, especially when these relate to their own experiences.

Source: MSDE, School Readiness Reports, Appendix A.

Appendix B. Correlation matrix for independent student variables.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Birth weight (1)	1.00						
NBW (2)	0.71*	1.00					
LBW (3)	-0.71*	-1.00*	1.00				
MLBW (4)	-0.53*	-0.90*	0.90*	1.00			
VLBW (5)	-0.35*	-0.30*	0.30*	-0.04*	1.00		
ELBW (6)	-0.36*	-0.25*	0.25*	-0.04*	-0.01^	1.00	
Gestational age (7)	0.71*	0.63*	-0.63*	-0.39*	-0.40*	-0.47*	1.00
Full-term (8)	0.46*	0.38*	-0.38*	-0.33*	-0.14*	-0.11*	0.67*
PTB (9)	-0.58*	-0.60*	0.60*	0.48*	0.28*	0.23*	-0.77*
Post-term (10)	0.06*	0.03*	-0.03*	-0.03*	-0.01	-0.01	0.14*
Early-term (11)	-0.07*	0.05*	-0.05*	-0.01	-0.07*	-0.06*	-0.16*
MPTB (12)	-0.29*	-0.35*	0.35*	0.39*	-0.01*	-0.03*	-0.39*
VPTB (13)	-0.43*	-0.46*	0.46*	0.29*	0.47*	0.09*	-0.56*
EPTB (14)	-0.35*	-0.24*	0.24*	-0.03*	0.15*	0.77*	-0.49*
District PK (15)	0.01^	0.02*	-0.02*	-0.01	-0.01^	-0.01*	0.01^
Informal Home (16)	-0.03*	-0.03*	0.03*	0.02*	0.01^	0.01^	-0.02*
Head Start (17)	-0.02*	-0.01^	0.01^	0.01	0.01^	0.01*	-0.02*
Child care center (18)	0.02*	0.01^	-0.01^	-0.01^	0.00	-0.01	0.01*
Family child care (19)	-0.01	-0.01	0.01	0.01	0.00	0.00	-0.01
Private nursery PK (20)	0.04*	0.02*	-0.02*	-0.02*	-0.01	-0.01	0.03*
Other PK (21)	0.01^	0.01	-0.01	-0.01^	0.00	0.01	0.01*
NH Black (22)	-0.11*	-0.05*	0.05*	0.04*	0.02*	0.02*	-0.07*
NH White (23)	0.09*	0.04*	-0.04*	-0.03*	-0.02*	-0.01^	0.05*
Hispanic (24)	0.06*	0.04*	-0.04*	-0.03*	-0.01^	-0.02*	0.04*
NH Asian (25)	0.00	0.01	-0.01	-0.01^	0.00	0.00	0.00
NH Other (26)	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Female (27)	-0.10*	-0.05*	0.05*	0.04*	0.01^	0.01^	0.00

* $p < 0.01$ ^ $p < 0.05$

Appendix B. Correlation matrix for independent student variables (continued).

	(8)	(9)	(10)	(11)	(12)	(13)	(14)
PTB (9)	1.00						
Post-term (10)	-0.47*	1.00					
Early-term (11)	-0.11*	-0.04*	1.00				
Early-term (11)	-0.71*	-0.26*	-0.06*	1.00			
MPTB (12)	-0.38*	0.80*	-0.03*	-0.21*	1.00		
VPTB (13)	-0.23*	0.48*	-0.02*	-0.12*	-0.07*	1.00	
EPTB (14)	-0.11*	0.23*	-0.01	-0.06*	-0.03*	-0.02*	1.00
District PK (15)	0.00	-0.01*	-0.01	0.01	-0.01	-0.01	-0.02*
Informal Home (16)	-0.02*	0.03*	0.01	0.00	0.01*	0.02*	0.02*
Head Start (17)	-0.01	0.01^	0.00	0.00	0.01	0.00	0.01*
Child care center (18)	0.01	-0.01	0.00	0.00	0.00	-0.01^	-0.01^
Family child care (19)	0.00	0.01	-0.01	0.00	0.00	0.01	0.00
Private nursery PK (20)	0.02*	-0.02*	0.01*	-0.01^	-0.02*	-0.01	-0.01
Other PK (21)	0.02*	-0.02*	0.00	0.00	-0.01*	-0.01	0.00
NH Black (22)	-0.06*	0.04*	-0.02*	0.03*	0.02*	0.03*	0.02*
NH White (23)	0.04*	-0.03*	0.02*	-0.03*	-0.01*	-0.03*	-0.01*
Hispanic (24)	0.03*	-0.03*	0.01	-0.01^	-0.02*	-0.02*	-0.01*
NH Asian (25)	0.00	0.00	-0.01	0.00	0.00	0.00	0.00
NH Other (26)	0.01^	0.00	0.00	-0.01^	0.00	0.00	0.00
Female (27)	0.00	0.00	-0.01	0.00	0.00	0.00	0.01

* $p < 0.01$ ^ $p < 0.05$

Appendix B. Correlation matrix for independent student variables (continued).

	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)
District PK (15)	1.00												
Informal Home (16)	-0.54*	1.00											
Head Start (17)	-0.37*	-0.20*	1.00										
Child care center (18)	-0.22*	-0.12*	-0.08*	1.00									
Family child care (19)	-0.17*	-0.09*	-0.06*	-0.04*	1.00								
Private nursery PK (20)	-0.16*	-0.09*	-0.06*	-0.04*	-0.03*	1.00							
Other PK (21)	-0.24*	-0.13*	-0.09*	-0.05*	-0.04*	-0.04*	1.00						
NH Black (22)	0.03*	-0.01	0.06*	0.00	0.00	-0.19*	-0.01	1.00					
NH White (23)	-0.06*	0.02*	-0.07*	0.02*	0.01	0.23*	0.02*	-0.82*	1.00				
Hispanic (24)	0.03*	-0.01	0.00	-0.03*	-0.01	-0.01*	-0.01*	-0.47*	-0.06*	1.00			
NH Asian (25)	0.00	0.00	-0.01	0.01	0.00	0.02*	-0.01^	-0.16*	-0.02*	-0.01^	1.00		
NH Other (26)	0.00	0.00	0.00	0.00	0.00	-0.01	0.00	-0.15*	-0.02*	-0.01^	0.00	1.00	
Female (27)	0.01	-0.01*	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01	1.00

* $p < 0.01$ ^ $p < 0.05$

Appendix B. Correlation matrix for independent student variables (continued).

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Age (28)	-0.01*	-0.01	0.01	0.00	0.01	0.00	-0.01
Age <5 (29)	0.01	0.00	0.00	0.00	0.00	0.00	0.01
Age=5 (30)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Age >5 (31)	-0.01^	-0.01^	0.01^	0.01	0.00	0.01	-0.01
FARMS (32)	-0.05*	-0.02*	0.02*	0.02*	0.01^	-0.01	-0.03*
SWD (33)	-0.04*	-0.05*	0.05*	0.02*	0.02*	0.08*	-0.07*
Missing SWD (34)	0.00	0.00	0.00	0.00	0.00	0.01	0.00
ELL (35)	0.05*	0.03*	-0.03*	-0.03*	0.00	-0.01	0.03*
Birth order (36)	-0.03*	-0.06*	0.06*	0.06*	0.01^	0.01	-0.10*
First born (37)	-0.01	0.02*	-0.02*	-0.02*	0.00	0.00	0.07*
One sibling (38)	0.04*	0.03*	-0.03*	-0.03*	-0.01	-0.01*	0.02*
2+ siblings (39)	-0.03*	-0.05*	0.05*	0.05*	0.01^	0.01	-0.09*
Siblings missing (40)	-0.01	0.00	0.00	0.00	0.00	0.00	-0.01
Multiple birth (41)	-0.27*	-0.29*	0.29*	0.26*	0.11*	0.07*	-0.25*
Apgar @ 1 min. (42)	0.02*	0.02*	-0.02*	0.00	-0.03*	-0.05*	0.04*
Apgar @ 5 mins. (43)	0.00	0.00	0.00	0.01	-0.01	-0.02*	0.02*
# Abnormal conditions (44)	-0.13*	-0.13*	0.13*	0.06*	0.09*	0.17*	-0.18*
Anemia (45)	-0.03*	-0.03*	0.03*	0.02*	0.00	0.04*	-0.04*
Assisted Ventilation (46)	-0.15*	-0.12*	0.12*	0.02*	0.12*	0.22*	-0.20*
# Complications (47)	-0.08*	-0.09*	0.09*	0.05*	0.07*	0.08*	-0.09*
Breech/mal-presentation (48)	-0.14*	-0.13*	0.13*	0.07*	0.08*	0.12*	-0.17*
Fetal distress (49)	-0.03*	-0.02*	0.02*	0.01^	0.02*	0.03*	-0.01
Placenta previa (50)	-0.05*	-0.05*	0.05*	0.04*	0.03*	0.03*	-0.07*

* $p < 0.01$ ^ $p < 0.05$

Appendix B. Correlation matrix for independent student variables (continued).

	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Age (28)	-0.01	0.01	0.00	0.00	0.01	0.00	0.01
Age <5 (29)	0.01^	0.00	0.01^	-0.01^	0.00	0.00	0.00
Age=5 (30)	-0.01	0.00	-0.02*	0.01*	0.00	0.00	-0.01
Age >5 (31)	-0.01	0.01^	0.02*	0.00	0.00	0.01	0.01^
FARMS (32)	-0.03*	0.02*	-0.01^	0.02*	0.02*	0.01^	0.00
SWD (33)	-0.03*	0.04*	0.00	0.00	0.01	0.03*	0.07*
Missing SWD (34)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ELL (35)	0.03*	-0.02*	0.01*	-0.02*	-0.02*	-0.01^	-0.01
Birth order (36)	-0.10*	0.08*	-0.01	0.04*	0.07*	0.05*	0.01
First born (37)	0.08*	-0.05*	0.02*	-0.05*	-0.05*	-0.02*	0.00
One sibling (38)	0.00	-0.02*	-0.01	0.02*	-0.01^	-0.02*	-0.01*
2+ siblings (39)	-0.09*	0.07*	-0.01^	0.04*	0.06*	0.04*	0.01^
Siblings missing (40)	-0.01	0.01	-0.01	0.00	0.01	0.01	0.00
Multiple birth (41)	-0.19*	0.26*	-0.01*	0.01*	0.18*	0.15*	0.08*
Apgar @ 1 min. (42)	0.01	-0.03*	0.00	0.02*	0.00	-0.03*	-0.05*
Apgar @ 5 mins. (43)	0.00	-0.01*	0.00	0.01	0.00	-0.01	-0.02*
# Abnormal conditions (44)	-0.07*	0.14*	0.00	-0.03*	0.04*	0.10*	0.18*
Anemia (45)	-0.02*	0.03*	0.00	0.00	0.00	0.03*	0.04*
Assisted Ventilation (46)	-0.05*	0.13*	0.00	-0.04*	0.00	0.11*	0.24*
# Complications (47)	-0.01^	0.09*	0.00	-0.06*	0.03*	0.09*	0.08*
Breech/mal-presentation (48)	-0.09*	0.13*	-0.01^	0.00	0.06*	0.09*	0.12*
Fetal distress (49)	0.01	0.01	0.01	-0.02*	0.00	0.02*	0.01^
Placenta previa (50)	-0.04*	0.06*	0.00	0.00	0.02*	0.06*	0.03*

* $p < 0.01$ ^ $p < 0.05$

Appendix B. Correlation matrix for independent student variables (continued).

	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Age (28)	0.05*	-0.04*	-0.01	-0.03*	-0.02*	0.00	0.00
Age <5 (29)	-0.05*	0.05*	-0.01^	0.01^	0.01*	0.00	0.01
Age=5 (30)	0.07*	-0.08*	0.02*	-0.01	-0.02*	0.00	-0.02*
Age >5 (31)	-0.08*	0.09*	-0.02*	-0.01	0.01^	0.02*	0.02*
FARMS (32)	0.09*	0.02*	0.04*	-0.07*	-0.01	-0.22*	-0.06*
SWD (33)	0.05*	-0.04*	0.02*	-0.03*	-0.02*	-0.02*	0.00
Missing SWD (34)	-0.06*	0.08*	-0.02*	0.01*	0.04*	-0.01	-0.01
ELL (35)	0.03*	-0.01^	-0.01	-0.02*	0.00	-0.02*	0.00
Birth order (36)	0.00	0.06*	-0.03*	-0.03*	0.00	-0.05*	-0.02*
First born (37)	-0.04*	-0.03*	0.04*	0.03*	-0.01	0.03*	0.02*
One sibling (38)	0.03*	-0.02*	-0.02*	0.00	0.00	0.02*	-0.01
2+ siblings (39)	0.01	0.05*	-0.02*	-0.04*	0.01^	-0.05*	-0.02*
Siblings missing (40)	0.00	0.00	0.00	0.00	0.01	0.00	0.00
Multiple birth (41)	-0.01^	0.00	0.02*	0.00	0.00	0.01	-0.01
Apgar @ 1 min. (42)	0.01	0.00	-0.01	-0.01	0.00	0.00	0.01
Apgar @ 5 mins. (43)	0.00	0.00	-0.01	-0.01	-0.01	0.00	0.01
# Abnormal conditions (44)	-0.03*	0.01^	0.00	0.02*	0.00	0.02*	0.00
Anemia (45)	0.00	0.00	0.00	0.01	0.00	0.00	-0.01
Assisted Ventilation (46)	-0.02*	0.01^	0.00	0.00	0.00	0.00	0.01
# Complications (47)	-0.01*	0.00	0.00	0.01^	0.00	0.00	0.01*
Breech/mal-presentation (48)	-0.01	0.00	-0.01	0.02*	0.01	0.00	0.00
Fetal distress (49)	-0.01	0.00	0.00	0.02*	0.00	0.00	0.01
Placenta previa (50)	0.00	0.00	-0.01	0.01^	0.00	0.00	-0.01

* $p < 0.01$ ^ $p < 0.05$

Appendix B. Correlation matrix for independent student variables (continued).

	(22)	(23)	(24)	(25)	(26)	(27)	(28)
Age (28)	-0.01^	0.01	0.01*	-0.01	-0.01	-0.02*	1.00
Age <5 (29)	0.00	0.01	-0.03*	0.01	0.01	0.02*	-0.48*
Age=5 (30)	0.00	-0.02*	0.02*	-0.01	-0.01	-0.02*	0.36*
Age >5 (31)	-0.03*	0.02*	0.01	0.00	0.00	-0.01*	0.28*
FARMS (32)	0.21*	-0.25*	0.03*	-0.04*	-0.01	0.01	0.03*
SWD (33)	-0.01*	0.02*	-0.01^	0.00	0.00	-0.11*	0.00
Missing SWD (34)	0.01*	0.00	-0.03*	0.00	0.00	0.00	-0.08*
ELL (35)	-0.31*	-0.03*	0.61*	0.10*	0.00	0.00	-0.01
Birth order (36)	0.05*	-0.05*	0.00	-0.02*	-0.01	0.00	0.02*
First born (37)	-0.03*	0.03*	-0.01	0.01^	0.01	0.00	0.00
One sibling (38)	-0.02*	0.02*	0.01	0.01	0.00	-0.01^	-0.02*
2+ siblings (39)	0.05*	-0.05*	0.00	-0.02*	0.00	0.01	0.02*
Siblings missing (40)	0.00	0.00	0.00	0.00	0.00	0.00	-0.03*
Multiple birth (41)	0.00	0.01^	-0.01*	-0.01	-0.01	0.01*	0.02*
Apgar @ 1 min. (42)	0.00	0.00	0.00	0.00	0.00	0.01	0.01
Apgar @ 5 mins. (43)	0.01	-0.01	0.00	0.00	0.00	0.01	0.01^
# Abnormal conditions (44)	-0.01	0.02*	-0.02*	0.00	0.00	0.00	0.00
Anemia (45)	0.01	-0.01	0.00	0.00	0.00	0.01	-0.01
Assisted Ventilation (46)	0.00	0.00	0.00	0.00	0.00	-0.01	0.00
# Complications (47)	0.00	0.00	0.00	0.00	0.00	-0.01^	0.01*
Breech/mal-presentation (48)	-0.03*	0.03*	0.00	0.00	0.00	0.01	0.01*
Fetal distress (49)	0.02*	-0.01^	-0.01*	0.00	0.00	-0.02*	0.00
Placenta previa (50)	0.00	0.00	0.00	0.00	0.00	0.00	0.00

* $p < 0.01$ ^ $p < 0.05$

Appendix B. Correlation matrix for independent student variables (continued).

	(29)	(30)	(31)	(32)	(33)	(34)	(35)
Age <5 (29)	1.00						
Age=5 (30)	-0.94*	1.00					
Age >5 (31)	-0.03*	-0.31*	1.00				
FARMS (32)	-0.04*	0.04*	-0.01*	1.00			
SWD (33)	0.00	0.01	0.00	0.01	1.00		
Missing SWD (34)	0.09*	-0.09*	-0.01	0.01	-0.05*	1.00	
ELL (35)	-0.01^	0.01	0.01^	0.02*	-0.01^	-0.02*	1.00
Birth order (36)	-0.01^	0.00	0.03*	0.12*	0.02*	0.00	-0.01
First born (37)	0.00	0.00	-0.01^	-0.10*	-0.02*	-0.01	-0.01
One sibling (38)	0.01	0.00	-0.01^	-0.02*	0.00	0.00	0.01^
2+ siblings (39)	-0.01*	0.01	0.02*	0.12*	0.02*	0.00	0.00
Siblings missing (40)	0.04*	-0.04*	0.00	0.00	0.00	0.00	0.00
Multiple birth (41)	-0.01^	0.01	0.01^	0.01	0.04*	-0.01	-0.01
Apgar @ 1 min. (42)	0.00	0.00	0.01^	0.00	0.00	-0.01	0.01
Apgar @ 5 mins. (43)	0.00	-0.01	0.01*	0.00	0.00	-0.01	0.00
# Abnormal conditions (44)	0.01*	-0.01*	0.00	-0.05*	0.02*	0.00	-0.01
Anemia (45)	0.01	0.00	0.00	0.00	0.00	-0.01	0.01
Assisted Ventilation (46)	0.01*	-0.01*	0.00	0.00	0.03*	0.00	0.00
# Complications (47)	0.01	-0.01	0.00	-0.03*	0.01^	0.00	0.00
Breech/mal-presentation (48)	0.00	0.00	0.01	-0.02*	0.01^	0.00	-0.01
Fetal distress (49)	0.00	0.00	0.00	-0.01*	0.01	0.00	-0.01
Placenta previa (50)	0.00	0.00	0.00	0.00	0.00	0.00	0.00

* $p < 0.01$ ^ $p < 0.05$

Appendix B. Correlation matrix for independent student variables (continued).

	(36)	(37)	(38)	(39)	(40)	(41)	(42)	(43)	(44)	(45)	(46)	(47)	(48)	(49)
Birth order (36)	1.00													
First born (37)	-0.69*	1.00												
One sibling (38)	-0.10*	-0.51*	1.00											
2+ siblings (39)	0.81*	-0.54*	-0.44*	1.00										
Siblings missing (40)		-0.05*	-0.04*	-0.04*	1.00									
Multiple birth (41)	0.10*	-0.09*	0.00	0.09*	0.00	1.00								
Apgar @ 1 min. (42)	0.04*	-0.03*	0.00	0.03*	0.00	-0.02*	1.00							
Apgar @ 5 mins. (43)	0.03*	-0.02*	0.00	0.03*	0.00	-0.01^	0.94*	1						
# Abnormal conditions (44)	0.00	0.01^	-0.01*	0.00	0.03*	0.06*	-0.03*	-0.01	1					
Anemia (45)	0.00	0.00	-0.01	0.00	0.01^	0.01^	-0.01*	-0.01	0.22*	1				
Assisted Ventilation (46)	0.00	0.00	-0.01^	0.01	0.02*	0.04*	-0.06*	-0.03*	0.49*	0.11*	1			
# Complications (47)	-0.03*	0.07*	-0.04*	-0.03*	-0.01*	0.04*	-0.05*	-0.01*	0.15*	0.02*	0.11*	1		
Breech/mal-presentation (48)	0.03*	-0.02*	-0.01	0.03*	-0.01	0.23*	-0.04*	-0.02*	0.08*	0.01^	0.08*	0.26*	1	
Fetal distress (49)	-0.03*	0.04*	-0.02*	-0.02*	0.00	-0.02*	-0.04*	-0.02*	0.08*	0.02*	0.05*	0.35*	0	1
Placenta previa (50)	0.02*	-0.02*	0.00	0.02*	0.00	0.00	-0.01^	-0.01	0.03*	0	0.02*	0.08*	0.01	0.01^

* p < 0.01 ^ p < 0.05

Appendix C. Correlation matrix for independent parent variables.

	(1)	(2)	(3)	(4)	(5)	(6)
Maternal Race: NH Black (1)	1.00					
Maternal Race: NH White (2)	-0.85*	1.00				
Maternal Race: Hispanic (3)	-0.41*	-0.06*	1.00			
Maternal Race: Asian (4)	-0.06*	-0.01	0.00	1.00		
Maternal Race: Missing (5)	-0.05*	-0.01	0.00	0.00	1.00	
Paternal Race: NH Black (6)	0.37*	-0.31*	-0.16*	-0.03*	-0.02*	1.00
Paternal Race: NH White (7)	-0.67*	0.77*	-0.03*	0.01*	0.00	-0.32*
Paternal Race: Hispanic (8)	0.03*	-0.12*	0.19*	-0.01*	-0.01	-0.81*
Paternal Race: Asian (9)	-0.05*	0.00	0.00	0.71*	0.00	-0.02*
Paternal Race: Missing (10)	0.01^	-0.01*	-0.02*	0.00	0.13*	-0.12*
Maternal education, yrs (11)	0.00	0.10*	-0.20*	0.02*	0.00	0.11*
Maternal education < 12 yrs (12)	-0.03*	-0.01	0.09*	-0.01	0.00	-0.11*
Maternal education = 12 yrs (13)	0.10*	-0.08*	-0.06*	-0.01	0.00	0.05*
Maternal education > 12 yrs (14)	-0.09*	0.11*	-0.04*	0.02*	0.00	0.06*
Maternal education missing (15)	0.01^	-0.02*	0.02*	0.00	0.01	0.04*
Paternal education, yrs (16)	-0.04*	0.12*	-0.20*	0.04*	-0.01	-0.03*
Paternal education < 12 yrs (17)	-0.10*	0.07*	0.09*	-0.01	0.00	0.21*
Paternal education = 12 yrs (18)	0.05*	-0.03*	-0.05*	-0.01	0.00	0.47*
Paternal education > 12 yrs (19)	-0.16*	0.17*	-0.02*	0.04*	-0.01	0.12*
Paternal education missing (20)	0.13*	-0.13*	-0.01	-0.01*	0.01	-0.68*
Maternal age, continuous (21)	-0.15*	0.14*	0.03*	0.03*	0.00	0.01
Maternal age < 20 (22)	0.10*	-0.08*	-0.05*	-0.02*	0.00	-0.02*
Maternal age 20 - 35 (23)	-0.05*	0.03*	0.05*	0.01^	0.00	0.02*
Maternal age > 35 (24)	-0.08*	0.09*	-0.01^	0.01	-0.01	-0.01
Maternal age missing (25)	0.00	0.00	0.00	0.00	0.00	0.01
Paternal age, continuous (26)	-0.14*	0.13*	0.01^	0.02*	0.00	-0.08*
Paternal age < 20 (27)	0.05*	-0.03*	-0.03*	-0.01	-0.01	0.15*
Paternal age 20 - 35 (28)	-0.06*	0.05*	0.04*	0.01	0.00	0.38*
Paternal age > 35 (29)	-0.11*	0.12*	-0.01	0.01*	0.00	0.09*
Paternal age missing (30)	0.12*	-0.11*	-0.02*	-0.01^	0.00	-0.57*
Not Married (31)	0.27*	-0.25*	-0.07*	-0.05*	0.00	-0.10*
Maternal tobacco use (32)	-0.09*	0.14*	-0.05*	-0.01	0.00	-0.07*
Missing tobacco use (33)	0.01	0.00	-0.01	0.00	0.00	0.03*
# Maternal medical factors (34)	0.01*	0.00	-0.04*	-0.01	-0.01	0.04*
Anemia (35)	0.01^	-0.01*	0.00	-0.01	0.00	0.02*
Gestational diabetes (36)	-0.02*	0.01^	0.00	0.01	0.00	0.02*
Eclampsia (37)	0.01^	-0.01	0.00	0.00	0.00	0.01*
Previous PTB (38)	0.02*	-0.01*	-0.01*	0.00	0.00	0.02*
Missing paternal data (39)	0.11*	-0.10*	-0.02*	-0.01^	0.00	-0.60*
Foreign born mother (40)	-0.30*	-0.02*	0.58*	0.10*	-0.01	-0.10*
Missing mother nativity (41)	0.01^	-0.01*	0.00	0.00	0.00	0.03*
Foreign born father (42)	-0.26*	0.03*	0.41*	0.08*	0.00	-0.06*
Missing father nativity (43)	0.12*	-0.12*	-0.01*	-0.01^	0.00	-0.63*

* $p < 0.01$ ^ $p < 0.05$

Appendix C. Correlation matrix for independent parent variables (continued).

	(7)	(8)	(9)	(10)	(11)	(12)
Paternal Race: NH White (7)	1.00					
Paternal Race: Hispanic (8)	-0.22*	1.00				
Paternal Race: Asian (9)	-0.01	-0.02*	1.00			
Paternal Race: Missing (10)	-0.03*	-0.08*	0.00	1.00		
Maternal education, yrs (11)	0.16*	-0.20*	0.01	-0.02*	1.00	
Maternal education < 12 yrs (12)	-0.05*	0.14*	-0.01	0.02*	-0.70*	1.00
Maternal education = 12 yrs (13)	-0.07*	-0.01^	-0.01	0.00	0.09*	-0.64*
Maternal education > 12 yrs (14)	0.15*	-0.15*	0.01*	-0.02*	0.72*	-0.38*
Maternal education missing (15)	-0.02*	-0.03*	0.01	0.00		-0.10*
Paternal education, yrs (16)	0.15*	-0.20*	0.02*	-0.02*	0.57*	-0.35*
Paternal education < 12 yrs (17)	0.09*	-0.26*	0.00	-0.03*	-0.21*	0.22*
Paternal education = 12 yrs (18)	0.00	-0.47*	0.00	-0.06*	0.08*	-0.17*
Paternal education > 12 yrs (19)	0.23*	-0.26*	0.03*	-0.03*	0.41*	-0.22*
Paternal education missing (20)	-0.21*	0.82*	-0.02*	0.10*	-0.19*	0.14*
Maternal age, continuous (21)	0.17*	-0.11*	0.02*	-0.02*	0.35*	-0.29*
Maternal age < 20 (22)	-0.09*	0.07*	-0.01*	0.01	-0.30*	0.30*
Maternal age 20 - 35 (23)	0.03*	-0.04*	0.01^	0.00	0.20*	-0.23*
Maternal age > 35 (24)	0.11*	-0.05*	0.00	-0.01^	0.15*	-0.09*
Maternal age missing (25)	0.00	-0.01	0.00	0.00	0.00	-0.01^
Paternal age, continuous (26)	0.15*	-0.04*	0.01^	-0.01	0.25*	-0.20*
Paternal age < 20 (27)	-0.03*	-0.13*	-0.01	-0.02*	-0.15*	0.15*
Paternal age 20 - 35 (28)	0.08*	-0.43*	0.01*	-0.06*	0.14*	-0.16*
Paternal age > 35 (29)	0.15*	-0.18*	0.01	-0.02*	0.16*	-0.10*
Paternal age missing (30)	-0.17*	0.68*	-0.01*	0.09*	-0.17*	0.16*
Not Married (31)	-0.32*	0.29*	-0.04*	0.03*	-0.30*	0.20*
Maternal tobacco use (32)	0.07*	0.03*	-0.01	0.01	-0.13*	0.14*
Missing tobacco use (33)	0.00	-0.02*	0.00	0.00	-0.01*	0.00
# Maternal medical factors (34)	0.00	-0.04*	0.00	-0.02*	0.06*	-0.03*
Anemia (35)	-0.02*	-0.01	0.00	0.00	0.00	0.00
Gestational diabetes (36)	0.02*	-0.03*	0.01^	-0.01*	0.05*	-0.05*
Eclampsia (37)	-0.01	-0.01	0.00	-0.01	0.00	0.01
Previous PTB (38)	-0.01	-0.02*	0.00	-0.01	-0.01	0.00
Missing paternal data (39)	-0.17*	0.71*	-0.01*	0.09*	-0.17*	0.15*
Foreign born mother (40)	0.01*	0.08*	0.09*	-0.02*	-0.07*	0.01^
Missing mother nativity (41)	-0.02*	-0.02*	0.00	-0.01	-0.02*	0.01^
Foreign born father (42)	0.01^	0.03*	0.09*	-0.02*	-0.04*	0.00
Missing father nativity (43)	-0.19*	0.75*	-0.02*	0.09*	-0.17*	0.14*

* $p < 0.01$ ^ $p < 0.05$

Appendix C. Correlation matrix for independent parent variables (continued).

	(13)	(14)	(15)	(16)	(17)	(18)
Maternal education = 12 yrs (13)	1.00					
Maternal education > 12 yrs (14)	-0.43*	1.00				
Maternal education missing (15)	-0.11*	-0.07*	1.00			
Paternal education, yrs (16)	-0.05*	0.43*	-0.02*	1.00		
Paternal education < 12 yrs (17)	-0.09*	-0.13*	-0.03*	-0.63*	1.00	
Paternal education = 12 yrs (18)	0.20*	-0.02*	-0.06*	-0.02^	-0.30*	1.00
Paternal education > 12 yrs (19)	-0.14*	0.44*	-0.04*	0.72*	-0.16*	-0.25*
Paternal education missing (20)	-0.02*	-0.17*	0.10*		-0.37*	-0.55*
Maternal age, continuous (21)	0.05*	0.28*	-0.02*	0.29*	-0.13*	0.06*
Maternal age < 20 (22)	-0.11*	-0.24*	0.02*	-0.20*	0.12*	-0.09*
Maternal age 20 - 35 (23)	0.11*	0.15*	-0.02*	0.10*	-0.09*	0.08*
Maternal age > 35 (24)	-0.02*	0.14*	-0.01^	0.15*	-0.05*	0.00
Maternal age missing (25)	-0.01	-0.01^	0.11*	-0.01	0.01	0.00
Paternal age, continuous (26)	0.00	0.22*	-0.01^	0.27*	-0.20*	0.03*
Paternal age < 20 (27)	-0.05*	-0.12*	0.02*	-0.20*	0.27*	-0.01
Paternal age 20 - 35 (28)	0.06*	0.12*	0.01	0.02*	0.11*	0.33*
Paternal age > 35 (29)	-0.01^	0.14*	0.00	0.17*	-0.03*	0.08*
Paternal age missing (30)	-0.02*	-0.15*	-0.02*	-0.05*	-0.27*	-0.41*
Not Married (31)	0.05*	-0.30*	0.02*	-0.28*	0.02*	-0.11*
Maternal tobacco use (32)	-0.04*	-0.11*	-0.01	-0.10*	0.04*	-0.03*
Missing tobacco use (33)	-0.01	-0.01^	0.05*	-0.01^	0.01	0.00
# Maternal medical factors (34)	-0.02*	0.07*	-0.01^	0.05*	-0.02*	0.01*
Anemia (35)	-0.01	0.00	0.00	0.01	0.00	0.00
Gestational diabetes (36)	0.01*	0.04*	-0.01	0.02*	-0.01	0.03*
Eclampsia (37)	-0.02*	0.01^	0.01	0.00	0.01	0.00
Previous PTB (38)	0.00	-0.01^	0.00	0.00	0.00	0.01*
Missing paternal data (39)	-0.02*	-0.14*	-0.03*		-0.28*	-0.42*
Foreign born mother (40)	-0.05*	0.05*	0.01	-0.03*	0.03*	-0.04*
Missing mother nativity (41)	-0.02*	-0.02*	0.10*	-0.02^	0.01	0.01
Foreign born father (42)	-0.04*	0.05*	0.01^	-0.04*	0.07*	0.00
Missing father nativity (43)	-0.01*	-0.14*	-0.03*	-0.05*	-0.28*	-0.44*

* p < 0.01 ^ p < 0.05

Appendix C. Correlation matrix for independent parent variables (continued).

	(19)	(20)	(21)	(22)	(23)	(24)
Paternal education > 12 yrs (19)	1.00					
Paternal education missing (20)	-0.30*	1.00				
Maternal age, continuous (21)	0.26*	-0.13*	1.00			
Maternal age < 20 (22)	-0.16*	0.10*	-0.64*	1.00		
Maternal age 20 - 35 (23)	0.08*	-0.06*	0.30*	-0.86*	1.00	
Maternal age > 35 (24)	0.14*	-0.06*	0.58*	-0.15*	-0.38*	1.00
Maternal age missing (25)	-0.01	0.00		-0.01^	-0.03*	-0.01
Paternal age, continuous (26)	0.25*	-0.06*	0.75*	-0.48*	0.21*	0.42*
Paternal age < 20 (27)	-0.09*	-0.13*	-0.32*	0.40*	-0.33*	-0.08*
Paternal age 20 - 35 (28)	0.14*	-0.48*	0.00	-0.20*	0.27*	-0.16*
Paternal age > 35 (29)	0.21*	-0.19*	0.46*	-0.20*	-0.02*	0.39*
Paternal age missing (30)	-0.23*	0.74*	-0.12*	0.11*	-0.08*	-0.04*
Not Married (31)	-0.39*	0.36*	-0.38*	0.24*	-0.14*	-0.18*
Maternal tobacco use (32)	-0.09*	0.06*	0.14*	-0.09*	0.04*	0.08*
Missing tobacco use (33)	-0.01*	0.00	-0.01	0.01	-0.01	0.00
# Maternal medical factors (34)	0.05*	-0.03*	0.13*	-0.07*	0.03*	0.08*
Anemia (35)	0.01	0.00	0.01^	-0.01	0.00	0.01
Gestational diabetes (36)	0.03*	-0.04*	0.12*	-0.07*	0.03*	0.07*
Eclampsia (37)	0.00	-0.01	-0.01	0.01^	-0.01*	0.01
Previous PTB (38)	-0.01	-0.01	0.05*	-0.04*	0.03*	0.02*
Missing paternal data (39)	-0.23*	0.75*	-0.12*	0.10*	-0.07*	-0.04*
Foreign born mother (40)	0.09*	-0.05*	0.12*	-0.09*	0.06*	0.04*
Missing mother nativity (41)	-0.02*	0.00	-0.01	0.02*	-0.02*	0.01
Foreign born father (42)	0.12*	-0.13*	0.12*	-0.08*	0.05*	0.05*
Missing father nativity (43)	-0.25*	0.79*	-0.13*	0.10*	-0.07*	-0.05*

* $p < 0.01$ ^ $p < 0.05$

Appendix C. Correlation matrix for independent parent variables (continued).

	(25)	(26)	(27)	(28)	(29)	(30)
Maternal age missing (25)	1.00					
Paternal age, continuous (26)	0.00	1.00				
Paternal age < 20 (27)	0.00	-0.47*	1.00			
Paternal age 20 - 35 (28)	0.00	-0.26*	-0.32*	1.00		
Paternal age > 35 (29)	0.00	0.75*	-0.11*	-0.36*	1.00	
Paternal age missing (30)	0.00		-0.20*	-0.66*	-0.23*	1.00
Not Married (31)	-0.01	-0.36*	0.13*	-0.17*	-0.27*	0.29*
Maternal tobacco use (32)	0.00	0.14*	-0.06*	-0.07*	0.08*	0.06*
Missing tobacco use (33)	0.00	-0.01	0.02*	0.00	0.00	-0.02*
# Maternal medical factors (34)	-0.01	0.11*	-0.05*	-0.01	0.07*	-0.01^
Anemia (35)	0.01	0.01^	-0.01^	0.00	0.01	0.00
Gestational diabetes (36)	0.00	0.09*	-0.04*	0.02*	0.06*	-0.04*
Eclampsia (37)	0.00	-0.01	0.01*	-0.01^	0.00	0.00
Previous PTB (38)	0.00	0.03*	-0.02*	0.01	0.02*	-0.01
Missing paternal data (39)	0.00		-0.19*	-0.63*	-0.22*	0.96*
Foreign born mother (40)	0.01^	0.14*	-0.05*	0.01	0.10*	-0.05*
Missing mother nativity (41)	0.06*	-0.02*	0.02*	0.00	0.00	-0.01
Foreign born father (42)	0.01	0.14*	-0.04*	0.07*	0.13*	-0.14*
Missing father nativity (43)	-0.01	-0.05*	-0.17*	-0.58*	-0.21*	0.89*

p < 0.01 ^ p < 0.05

Appendix C. Correlation matrix for independent parent variables (continued).

	(31)	(32)	(33)	(34)	(35)	(36)
Not Married (31)	1.00					
Maternal tobacco use (32)	0.07*	1.00				
Missing tobacco use (33)	0.01*	-0.02*	1.00			
# Maternal medical factors (34)	-0.05*	0.05*	-0.02*	1.00		
Anemia (35)	0.00	0.02*	0.00	0.39*	1.00	
Gestational diabetes (36)	-0.07*	-0.01^	-0.01	0.33*	0.02*	1.00
Eclampsia (37)	0.00	-0.01	0.00	0.15*	0.01	0.00
Previous PTB (38)	0.00	0.06*	0.00	0.23*	0.02*	0.01*
Missing paternal data (39)	0.28*	0.05*	-0.02*	-0.01*	0.00	-0.04*
Foreign born mother (40)	-0.18*	-0.07*	0.00	-0.03*	-0.01	0.02*
Missing mother nativity (41)	0.02*	0.00	0.01^	-0.01^	-0.01^	0.00
Foreign born father (42)	-0.22*	-0.05*	0.00	-0.02*	-0.01^	0.02*
Missing father nativity (43)	0.32*	0.05*	-0.02*	-0.02*	0.00	-0.04*

* p < 0.01 ^ p < 0.05

Appendix C. Correlation matrix for independent parent variables (continued).

	(37)	(38)	(39)	(40)	(41)	(42)	(43)
Eclampsia (37)	1.00						
Previous PTB (38)	0.00	1.00					
Missing paternal data (39)	0.00	-0.01	1.00				
Foreign born mother (40)	0.00	-0.02*	-0.05*	1.00			
Missing mother nativity (41)	0.00	0.01	-0.01^	-0.02*	1.00		
Foreign born father (42)	0.00	-0.01	-0.14*	0.57*	0.00	1.00	
Missing father nativity (43)	0.00	-0.01	0.89*	-0.05*	0.00	-0.15*	1.00

* $p < 0.01$ ^ $p < 0.05$

Appendix D. Correlation matrix for neighborhood independent variables (across 55 neighborhoods).

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
% Female headed households, 2010 (1)	1.00									
Median household income, 2000 (2)	-0.79*	1.00								
Median household income, 2010 (3)	-0.88*	0.91*	1.00							
% Poverty, 2000 (4)	0.72*	-0.78*	-0.75*	1.00						
% Poverty, 2012 (5)	0.80*	-0.80*	-0.79*	0.74*	1.00					
% At least some college, 2000 (6)	-0.72*	0.80*	0.76*	-0.81*	-0.69*	1.00				
% At least some college, 2012 (7)	-0.78*	0.63*	0.78*	-0.65*	-0.57*	0.83*	1.00			
Unemployment rate, 2000 (8)	0.83*	-0.71*	-0.74*	0.68*	0.83*	-0.73*	-0.62*	1.00		
Unemployment rate, 2012 (9)	0.83*	-0.63*	-0.77*	0.69*	0.75*	-0.73*	-0.80*	0.84*	1.00	
Healthy food availability index, 2012 (10)	-0.31^	0.30^	0.39*	-0.29^	-0.28^	0.26	0.32^	-0.29^	-0.25	1.00

* $p < 0.01$ ^ $p < 0.05$

Appendix E. Multivariate estimated differences in mean standardized domain readiness scores and 95% confidence intervals (CI) of Baltimore City born kindergartners, fall 2002 to 2012, by low birth weight categories

Prior Care Setting	Language & Literacy	Mathematical Thinking	Social & Personal Development	Scientific Thinking	Social Studies	The Arts	Physical Development & Health
Intercept	0.37***	0.39***	0.06	0.29***	0.23***	0.15**	0.15**
	(0.30, 0.45)	(0.31, 0.47)	(0.00, 0.12)	(0.22, 0.36)	(0.16, 0.30)	(0.09, 0.21)	(0.08, 0.21)
MLBW	-0.08***	-0.08***	-0.05**	-0.08***	-0.08***	-0.05*	-0.05**
	(-0.11, -0.04)	(-0.11, -0.04)	(-0.09, -0.01)	(-0.11, -0.04)	(-0.11, -0.04)	(-0.08, -0.01)	(-0.09, -0.01)
VLBW	-0.11*	-0.12*	-0.06	-0.14**	-0.09	-0.04	-0.02
	(-0.21, -0.01)	(-0.22, -0.02)	(-0.17, 0.04)	(-0.24, -0.04)	(-0.19, 0.01)	(-0.14, 0.07)	(-0.12, 0.09)
ELBW	-0.36***	-0.36***	-0.22**	-0.39***	-0.31***	-0.17*	-0.20*
	(-0.53, -0.20)	(-0.52, -0.19)	(-0.39, -0.05)	(-0.56, -0.23)	(-0.47, -0.14)	(-0.34, -0.00)	(-0.37, -0.03)

Presented are estimated differences in mean standardized readiness scores with a mean=0 and standard deviation=1 by cohort year. 95% confidence intervals provided in paranthesis. Each model included random interceps for cohort years and schools, and adjust for the cohort entry year at the student level plus the following covariates: PTB categories, student's race, gender, age, disability status, non-FARMS status, number of siblings at birth, multiple birth, neonatal assisted ventilation, low Apgar scores, maternal and paternal race, maternal age, maternal years of education, missing paternal information, marital status, and maternal tobacco use.

Reference category: normal birth weight (NBW, $\geq$ 2500 grams). MLBW: 1500-2499 grams. VLBW: 1000-1499 grams. ELBW: <1000 grams).

*p < 0.05 **p < 0.01 ***p < 0.001

Appendix F. Multivariate estimated differences in mean standardized domain readiness scores and 95% confidence intervals (CI) of Baltimore City born kindergartners, fall 2002 to 2012, by preterm birth categories

Prior Care Setting	Language & Literacy	Mathematical Thinking	Social & Personal Development	Scientific Thinking	Social Studies	The Arts	Physical Development & Health
Intercept	0.37***	0.39***	0.06	0.29***	0.23***	0.15**	0.15**
	(0.30, 0.45)	(0.31, 0.47)	(0.00, 0.12)	(0.22, 0.36)	(0.16, 0.30)	(0.09, 0.21)	(0.08, 0.21)
Early-term	-0.03**	-0.04***	-0.02*	-0.04**	-0.02*	-0.03*	-0.03*
	(-0.05, -0.01)	(-0.06, -0.02)	(-0.05, -0.00)	(-0.06, -0.01)	(-0.05, -0.00)	(-0.05, -0.01)	(-0.05, -0.00)
Post-term	-0.12*	-0.09	-0.09	-0.07	-0.07	-0.10*	-0.12*
	(-0.22, -0.02)	(-0.19, 0.01)	(-0.19, 0.01)	(-0.17, 0.03)	(-0.17, 0.03)	(-0.21, -0.00)	(-0.22, -0.02)
MPTB	-0.04	-0.05*	-0.02	-0.03	-0.01	-0.02	-0.02
	(-0.07, 0.00)	(-0.08, -0.01)	(-0.06, 0.02)	(-0.06, 0.01)	(-0.04, 0.03)	(-0.06, 0.02)	(-0.06, 0.02)
VPTB	-0.08*	-0.06	-0.08*	-0.01	-0.03	-0.09*	-0.13***
	(-0.15, -0.02)	(-0.12, 0.01)	(-0.15, -0.01)	(-0.08, 0.05)	(-0.10, 0.04)	(-0.15, -0.02)	(-0.20, -0.06)
EPTB	-0.03	-0.03	-0.06	0.06	-0.03	-0.13	-0.27**
	(-0.20, 0.14)	(-0.20, 0.14)	(-0.23, 0.11)	(-0.12, 0.23)	(-0.20, 0.14)	(-0.30, 0.04)	(-0.44, -0.09)

Presented are estimated differences in mean standardized readiness scores with a mean=0 and standard deviation=1 by cohort year. 95% confidence intervals provided in paranthesis. Each model included random interceps for cohort years and schools, and adjust for the cohort entry year at the student level plus the following covariates: PTB categories, student's race, gender, age, disability status, non-FARMS status, number of siblings at birth, multiple birth, neonatal assisted ventilation, low Apgar scores, maternal and paternal race, maternal age, maternal years of education, missing paternal information, marital status, and maternal tobacco use.

Reference category: Full-term: 39 - 41 weeks Post-term: 42+ weeks. Early-term: 37-38 weeks. PTB: preterm birth, 37 weeks. MPTB: moderately PTB, 34 - 36 weeks. VPTB: very PTB, 28-33 weeks. EPTB: extremely PTB, <28 weeks.

*p < 0.05 **p < 0.01 ***p < 0.001

Table G. Multivariate estimated differences in mean standardized domain readiness scores and 95% confidence intervals (CI) of Baltimore City born kindergartners, fall 2002 to 2012, by preterm birth categories

Prior Care Setting	Language & Literacy	Mathematical Thinking	Social & Personal Development	Scientific Thinking	Social Studies	The Arts	Physical Development & Health
Intercept	0.37***	0.39***	0.06	0.29***	0.23***	0.15**	0.15**
	(0.30, 0.45)	(0.31, 0.47)	(0.00, 0.12)	(0.22, 0.36)	(0.16, 0.30)	(0.09, 0.21)	(0.08, 0.21)
Private nursery PK	-0.15***	-0.16***	-0.07	-0.07*	-0.11**	-0.04	-0.11**
	(-0.22, -0.08)	(-0.23, -0.09)	(-0.14, 0.00)	(-0.14, -0.01)	(-0.18, -0.04)	(-0.11, 0.03)	(-0.18, -0.04)
Other PK	-0.22***	-0.23***	-0.09***	-0.15***	-0.12***	-0.09***	-0.12***
	(-0.26, -0.18)	(-0.27, -0.19)	(-0.13, -0.04)	(-0.19, -0.10)	(-0.16, -0.08)	(-0.13, -0.05)	(-0.16, -0.07)
Head Start	-0.29***	-0.31***	-0.16***	-0.22***	-0.22***	-0.15***	-0.15***
	(-0.32, -0.26)	(-0.34, -0.28)	(-0.19, -0.13)	(-0.25, -0.18)	(-0.25, -0.18)	(-0.18, -0.12)	(-0.18, -0.12)
Child care center	-0.36***	-0.37***	-0.28***	-0.24***	-0.26***	-0.18***	-0.24***
	(-0.41, -0.32)	(-0.41, -0.32)	(-0.32, -0.23)	(-0.29, -0.20)	(-0.31, -0.22)	(-0.22, -0.13)	(-0.29, -0.19)
Family child care	-0.57***	-0.59***	-0.33***	-0.39***	-0.40***	-0.25***	-0.30***
	(-0.63, -0.52)	(-0.64, -0.53)	(-0.38, -0.27)	(-0.45, -0.34)	(-0.46, -0.34)	(-0.31, -0.19)	(-0.35, -0.24)
Informal home care	-0.58***	-0.58***	-0.29***	-0.41***	-0.40***	-0.29***	-0.33***
	(-0.60, -0.55)	(-0.61, -0.56)	(-0.32, -0.27)	(-0.43, -0.38)	(-0.43, -0.38)	(-0.31, -0.26)	(-0.35, -0.30)

Presented are estimated differences in mean standardized readiness scores with a mean=0 and standard deviation=1 by cohort year. 95% confidence intervals provided in paranthesis. Each model included random interceps for cohort years and schools, and adjust for the cohort entry year at the student level plus the following covariates: PTB categories, student's race, gender, age, disability status, non-FARMS status, number of siblings at birth, multiple birth, neonatal assisted ventilation, low Apgar scores, maternal and paternal race, maternal age, maternal years of education, missing paternal information, marital status, and maternal tobacco use.

Reference category: Full-term: 39 - 41 weeks Post-term: 42+ weeks. Early-term: 37-38 weeks. PTB: preterm birth, 37 weeks. MPTB: moderately PTB, 34 - 36 weeks. VPTB: very PTB, 28-33 weeks. EPTB: extremely PTB, <28 weeks.

*p < 0.05 **p < 0.01 ***p < 0.001

Lawrence D. Reid, MPH
Laurel, MD 20724
lreid7@jhu.edu

EDUCATION

PhD Candidate, 2015, **Johns Hopkins Bloomberg School of Public Health;** Baltimore, Maryland
Department: Population, Family, and Reproductive Health
Track: Population and Health (Social Epidemiology)
Dissertation: *Neonatal Outcomes Related to School Readiness in an Urban Kindergarten Population*

Master of Public Health, 2007, **University of Michigan School of Public Health;** Ann Arbor, Michigan
Concentration: Epidemiology
Master's Capstone Research Paper: *Maternal Nativity: A 2004 Comparison of Black Preterm Birth Risks*

Bachelor of Arts, 2005, **University of Michigan;** Ann Arbor, Michigan
Major: Sociology; Minor: African American Studies

SKILLS/CERTIFICATIONS

- Scientific writing and presentations.
- Epidemiologic research and statistical analysis
  - Hierarchical Linear Modeling; Multivariate Logistic regressions; Cox Proportional Hazards modeling; Repeated Measures modeling; Poisson regression models; Health Impact Assessment; Health Priority Setting; Health Program Evaluation; Survey Development and Analysis
- Demographic research methods
  - Life Tables; Cohort component projections; Segregation analyses.
- Expert in SAS Base 9.3, SAS SQL, and Research Methods.
- Proficient in ArcGIS, STATA, SPSS, R, Oracle, and UNIX commands.
- Skilled in Microsoft Office Suite: Access, Excel, Power Point, Publisher, and Word.
- Program for Education and Evaluation in Responsible Research and Scholarship (PEERRS) certificate.
- Health Insurance Portability and Accountability Act (HIPAA) certified.
- Family Educational Rights and Privacy Act (FERPA) certified.

RELEVANT EXPERIENCE

October 2014 to present; Maryland Department of Health & Mental Hygiene (DHMH), Baltimore, Maryland
Director, Maternal and Child Health Epidemiology
Managing the epidemiologic research efforts to help improve the programmatic data-driven decision making of the Maternal and Child Health Bureau (MCHB) which aims to improve the health of women, infants, children, and men of reproductive ages in Maryland.
Specific duties include:

- Directing the analysis of vital statistics to identify health outcome trends and gaps that can be addressed by MCHB funded programs.
- Analyzing Pregnancy Risk Assessment Monitoring System (PRAMS), Child Fatality Review, and Health Services Cost Review Commission (HSCRC) hospital discharge claims data.
- Providing data analysis support for Title V, Title X, and other grant applications for the MCHB.

- Writing and reviewing MCHB briefs and reports.

June 2011 to October 2014; Baltimore City Public Schools (BCPS), Baltimore, Maryland
Program Evaluator II
Produce analyses and reports for the Office of Accountability and Achievement (OAA) in order to help improve BCPS understanding of areas where the school system is excelling and areas where improvement is needed. Serve as the liaison for the BCPS – Baltimore Education Research Consortium (BERC) partnership.
Achievements Include:

- Longitudinal Academic Outcomes by Kindergarten Readiness: Linked first time kindergarten cohorts with later student performance on assessment exams and other BCPS data to analyze adjusted trends in student performance and behavior by school readiness groups.
    - Presented at the 2014 American Educational Research Association (AERA) Conference.
- MSA Investigation Analysis and Reports: produce analyses and reports documenting whether there is quantitative evidence of results consistent with signs of testing irregularities on the Maryland School Assessment (MSA) for alleged schools within BCPS.
- Deep Dive Analyses: linked student achievement data across years to identify alignments within and across assessment exams. Developed prediction models to estimate projected assessment pass rates based on prior student performance and characteristics.
- Created summary presentations, spreadsheets, analyses, and reports for NAEP, MSA, HSA, College Board (SAT, PSAT, AP), and MMSR Kindergarten Readiness student achievement data.

September 2010 to June 2011; Johns Hopkins Bloomberg School of Public Health Urban Health Institute, Baltimore, Maryland
Graduate Research Assistant
Supported efforts to link Baltimore area data and indicators to create reports on the health of Baltimore and other urban health related studies.
Achievements include:

- Completed background summary of early childhood development academic and behavioral risk factors and determinants.
- Completed data analysis on volunteering rates in Baltimore.
- Developed reports to summarize my findings.

February 2008 to 2010; Health Research & Analysis, LLC, Rockville, Maryland
Research Analyst
Supported the data acquisition, analysis and reporting of military relevant epidemiologic studies in collaboration with a team of epidemiologists/analysts. Helped develop epidemiologic data analysis plans by utilizing statistical techniques and epidemiologic methods for various research topics pertaining to US military personnel health. Regularly utilized SAS, Excel, PowerPoint, and Word to complete data analyses and interpretations, and to prepare tables, reports, and manuscripts, and presentations for reporting of findings.
Achievements include:

- Longitudinal Cancer Study of the Military Health System (MHS): analyze the incidence and prevalence of cancer in the MHS annually from 2002-2007 (approx. 350,000 patients). Assess whether there are significant differences for MHS Beneficiaries receiving care in military hospitals and civilian hospitals as determined by costs, treatment, mortality, and cancer related health complications.
    - Accepted presentation for the American Public Health Association's (APHA) 138th Annual Meeting and Exposition, November 2010, Denver, CO.

- Presented poster at Healthcare Innovations Program (HIP) 2010 Military Health System Conference January 25 - 28, 2010 National Harbor, Maryland.

- National Health Study of U.S. Veterans: helped analyze and recode open ended responses of a pilot study for a large national health survey of US Veterans.
- Enhanced Particulate Matter Study (EPMS): analyzed the effects of in-theater particulate matter (PM) levels on respiratory and cardiovascular outcomes among deployed military personnel stationed at specific PM monitoring sites in Southwest Asia.
  - Study presented at the 12th Annual Force Health Protection Conference August 2009 in Albuquerque, New Mexico.
- Deployment Health Study: designed and analyzed a study to assess the effect of multiple deployments on subsequent health outcomes among active duty military personnel.

June 2007 to August 2007; GlaxoSmithKline, Collegeville, Pennsylvania
Graduate Intern
Selected for new program between the University of Michigan School of Public Health and GlaxoSmithKline designed to introduce Epidemiology MPH students to pharmacoepidemiology research work. Conducted literature reviews and participated in team meetings which contributed to the drug development process. Developed and analyzed preterm birth risk study using the National Center for Health Statistics (NCHS) 2004 Natality (4,112,052 live birth records), US Environmental Protection Agency (EPA), and US Census Bureau Economic datasets.

- Presented poster of research titled: **"Maternal Nativity: A 2004 Comparison of Black Preterm Birth Risks"** at the 13^{th} Annual Maternal and Child Health Epidemiology Conference in Atlanta, Georgia (Centers for Disease Control and Prevention, CDC; December 12-14, 2007).

January 2006 to May 2007; University of Michigan Epidemiology Department, Ann Arbor, Michigan
Graduate Research Assistant
Assisted with the beginning stages of a retrospective study designed to evaluate indicators of state and county preparedness' to respond to natural disasters. Utilized Microsoft Excel formulas and features to collect and organize social, environmental, and economic data on all 3,000+ United States (US) counties for analysis. Performed relevant literature reviews and research.

- Learned valuable Microsoft Excel techniques and functions used to aggregate large datasets.

July 2005 to August 2005; Howard University Law School, Washington, D.C.
Robert Wood Johnson Foundation (RWJF) funded Organizational and Leadership Development Internship
Drug Policy Researcher and Intern: produced relevant substance abuse and drug policy research reports for the National African American Drug Policy Coalition (NAADPC) co-director, Judge Arthur Burnett Sr.

- Attended a National Institute of Health (NIH) conference and documented recently funded epidemiologic drug research results presented at the conference for NAADPC and Howard University faculty use.
- Contributed and edited content for publications and website.

CONSULTING

August 2012 to August 2013; Health Research & Analysis, LLC, Rockville, Maryland

- **Submariner Epidemiology Research Program (SERP)**
  Performed systematic literature review of articles related to health outcomes of submariners.
- **EPIC Military Health Study**
  Provide expertise and knowledge regarding Military Health System (MHS) data repository (MDR) for the acquiring and analysis needed for the project.

July 2012 to October 2012; Baltimore City Health Department (BCHD), Baltimore, Maryland
Neighborhood Health Profile Validation
Analyzed Vital Statistics data for the BCHD Epidemiology division to produce Baltimore city health profiles at the community statistical area (CSA) level which summarize health indicators across a variety of Mortality and Birth related indicators.

October 2007 to February 2008; Associated Black Charities (ABC), Baltimore, Maryland
Ryan White Client Level Analysis
Provided client level statistical analyses and reports for HIV/AIDS related services provided by the Ryan White Administrative Agent-- Baltimore Eligible Metropolitan Area (EMA). Achievements include:

- Client Level HIV Report: de-duplicated and analyzed Client Level Data files from 50 provider organizations funded by the Ryan White Administrative Agency for FY 2006.
    - Prepared a report which summarized client demographics and service utilization in accordance with evaluations provided by the Ryan White Administrative Agency.
- Grant Reviewer: Primary reviewer for grants for the federally sponsored Ryan White HIV/AIDS Part A programs for the greater Baltimore area.

PUBLICATIONS

- Abraham JH, DeBakey SF, **Reid LD** (2012). Does Deployment to Iraq and Afghanistan Affect Respiratory Health of U.S. Military Personnel? *Journal of Occupational and Environmental Medicine*, 54(6):740-745
- Baird CP, DeBakey SF, **Reid LD** (2012). Respiratory Health Status of U.S. Army Personnel Potentially Exposed to Smoke from 2003 Al-Mishraq Sulfur Plant Fire. *Journal of Occupational and Environmental Medicine*, 54(6):717-723

PRESENTATIONS

- **2014 Neonatal Outcomes Related to School Readiness in an Urban Population.** International Conference on Urban Education, Montego Bay, Jamaica [Accepted for Poster].
- **2014 School Readiness and Subsequent Academic Achievement among Kindergarten Students.** American Educational Research Association (AERA) Annual Conference, Philadelphia, Pennsylvania
- **2013 Education Kindergarten Readiness in Baltimore City Public Schools (BCPS).** Baltimore Neighborhood Indicators Alliance (BNIA) Data Day 2013 Panel Member
- **2012 Preterm Birth (PTB) Prediction using the National Survey of Family Growth (NSFG).** American Public Health Association (APHA) 140th Annual Meeting & Expo, San Francisco, California [Accepted for Poster]
- **2010 Colo-rectal Cancer Costs in the Military Health System (MHS): A Direct Care - Purchased Care comparison.** MHS Healthcare Innovations Program Conference Prince George's County, Maryland.
- **2008 A Study of Cancer in the Military Beneficiary Population FY 2002 Compared with FY 2005.** TMA Office of Clinical Operations. Falls Church, Virginia.
- **2007 Maternal Nativity: A 2004 Comparison of Black Preterm Birth Risks.** 13th Annual CDC MCH Epidemiology Conference Atlanta, Georgia.

AWARDS/HONORS

Summer 2013 & Spring 2014; Johns Hopkins Bloomberg School of Public Health, Baltimore, MD

Health Resources and Services Administration (HRSA), Maternal and Child Health Bureau, DHHS

- Awarded the Maternal and Child Health Epidemiology Training Fellowship for my proposed doctoral research using vital statistics data from the Maryland Department of Health & Mental Hygiene (DHMH).

January 2007 to December 2007; University of Michigan School of Public Health, Ann Arbor, Michigan
The Center for Research on Ethnicity, Culture, and Health (CRECH)

- Awarded a National Institutes of Health (NIH) "Promoting Ethnic Diversity in Public Health Training" Master's Training in Racial Health Disparities Academic Scholarship.

September 2001 to December 2005; University of Michigan, Ann Arbor, Michigan
Varsity Football Team Member
Recipient of full athletic scholarship to play football for the University of Michigan Wolverines.
Achievements include:

- Starting Linebacker during 2003 & 2004 Big Ten Conference Championship & Rose Bowl Seasons.
- Led the Wolverine Defense in tackles during 2003 Big Ten Championship season.
- 2004 All-Big Ten Conference Football Team Honorable Mention.
- Roger Zatkoff Award 2003: awarded to leading Michigan season linebacker.

MEMBERSHIPS/ACTIVITIES

- **Volunteer,** Doctoral Admissions Committee member, Johns Hopkins Bloomberg School of Public Health, Population, Family and Reproductive Health Department, December 2013 – February 2014
- **Journal Reviewer**. Peer reviewed an article for the Maternal and Child Health Journal, November 2013.
- **Volunteer,** helped build playground at KIPP Baltimore as part of KABOOM! And CarMax Foundation sponsored event, 2013.
- **Volunteer,** helped carryout BCPS "Pre-K at Play" city-wide hands-on learning activity at different Baltimore venues, 2013.
- **BCPS Institutional Review Board (IRB) Member**: reviewed and voted to approve or reject research proposals based on the merits defined by BCPS Leadership, 2012 - present.
- **Mentor**, The Brotherhood Alliance for Science and Education (BASE) – Johns Hopkins School of Medicine, 2010 – 2011.
- **Co-Conference Chair**, Public Health Students of African Descent (PHSAD)- University of Michigan School of Public Health, Ann Arbor, Michigan. September 2006- April 2007.
  Achievements include:
    - Secured a 2-year non-renewable grant from RWJF for Minority Health Conference development.
    - Increased conference attendance and awareness from previous year.
- **Member,** American Public Health Association, 2005- 2007.
- **Volunteer**, University of Michigan Hospital, Ann Arbor, Michigan. May 2003- July 2003.